Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Digital Television Distributed Transmission System Technologies	)	MB Docket No. 05-312

To: The Commission

PETITION OF THE PENNSYLVANIA STATE UNIVERSITY
FOR LIMITED RECONSIDERATION

The Pennsylvania State University (the "University"), by its undersigned counsel and pursuant to Section 1.429(a) of the Commission's Rules,[1] respectfully submits this Petition for Limited Reconsideration (the "Petition") of the Commission's *Report and Order* regarding Digital Television Distributed Transmission System Technologies, FCC 08-256, released November 7, 2008, in MB Docket No. 05-312 (the "*Report and Order*").[2] In support, the following is respectfully shown:

In the *Report and Order*, the Commission adopted rules for the use of distributed transmission system ("DTS") technologies in the digital television ("DTV") service.[3] In the course of the *Report and Order*, the Commission discussed its approval of "the use of a multiple

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[1] 47 C.F.R. § 1.429(a).

[2] *See Digital Television Distributed Transmission System Technologies,* Report and Order, MB Docket No. 05-312, FCC 08-256 (rel. Nov. 7, 2008). The publication of the *Report and Order* in the Federal Register occurred on December 5, 2008. *See* 73 Fed. Reg. 74,047 (Dec. 5, 2008). Thus, this Petition for Limited Reconsideration is timely under Sections 1.429(d) and 1.4(b)(1) of the FCC Rules. 47 C.F.R. §§ 1.4(b)(1) and 1.429(d).

[3] *Report* and Order, at para. 1.

DTV transmitter system using multiple channels under an experimental authorization."[4] In a related footnote, the Commission stated that:

> The Pennsylvania State University, NCE licensee of WPSU-DT, channel 15, Clearfield, PA, which was the first to build an experimental DTS system, applied for this system before the interim DTS policy was established, but has since allowed authority for this system to expire. *See* FCC File Nos. BPEXT-20010608ABD, BEPEXT-20020618ABG, and BEPEXT-20030805ARU.[5]

In point of fact and law, however, the University did not allow the authority for this system to expire. Rather, the University filed a timely application for a further one-year extension of the experimental authorization for its DTS system. In addition, upon the request of Commission staff, the University supplemented its application with additional materials. Under Section 307(c)(3) of the Communications Act of 1934, as amended,[6] a license shall be continued while an application for renewal of such license is pending.

The University, through its undersigned counsel, has contacted Commission staff on numerous occasions about the status of the pending application for extension of its experimental authorization for its DTS facility, but to the best knowledge of the University and its counsel, the application has not yet been acted upon by the Commission, and remains pending. Thus, the University is submitting this Petition requesting that the Commission issue an erratum to the *Report and Order* that revises footnote 19 in order accurately to reflect the fact that the University's application for extension of its experimental authorization, as amended, is still pending. The University's counsel is continuing to attempt to discuss a correction to the

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[4] *Report and Order*, at para. 7.

[5] *Id.* at para. 7, n. 19.

[6] 47 U.S.C. § 307(c)(3).

erroneous footnote 19 with Commission staff, but is filing this Petition in order to protect its rights.

I. LEGAL BASIS FOR THIS PETITION

The Commission will entertain a petition for reconsideration if it is based upon new evidence, changed circumstances, or if reconsideration is in the public interest.[7] Reconsideration as requested here by the University is justified in the public interest as contemplated by Section 1.429(b)(3). The Commission also has stated that "[r]econsideration is warranted . . . if the petitioner cites material errors of fact or law or presents new or previously unknown facts and circumstances which raise substantial or material questions of fact that were not considered and that otherwise warrant [the] review of [the] prior action."[8] As demonstrated in detail below, the reconsideration requested by the University herein is justified under this "material errors" standard.

The University is an "interested person" eligible to submit this Petition for limited reconsideration.[9] The University's interests are directly adversely affected by the erroneous footnote 19 embedded in the *Report and Order*.

II. THE UNIVERSITY SUBMITTED A TIMELY APPLICATION FOR EXTENSION OF ITS EXPERIMENTAL AUTHORIZATION – AN APPLICATION THAT REMAINS PENDING

The University was originally granted an experimental authorization from the Commission to construct and operate a DTS station whose facilities are located at Pine Grove

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[7] 47 C.F.R. § 1.429(b)(1)-(3); *In the Matter of Numbering Resource Optimization*, Fourth Order on Reconsideration, 22 FCC Rcd 8047, at para. 5 (rel. Apr. 26, 2007).

[8] *Lancaster Communications, Inc.*, 22 FCC Rcd 2438, at para. 20 (rel. Feb. 7, 2007).

[9] *Cf*. 47 C.F.R. § 1.429(a).

Mills, Pennsylvania on June 26, 2001.[10] The DTS station serves the community of State College, Pennsylvania by re-broadcasting the signal of the University's primary digital UHF noncommercial, educational television broadcasting station WPSU-DT on DTV Channel *15 at Clearfield, Pennsylvania (Facility Identification Number 66219). This authorization was extended by the Commission on August 9, 2002[11] and again on October 21, 2003.[12]

On October 20, 2004, the University submitted an application to the Commission that requested the Commission to extend the University's experimental authorization for the DTS station for one additional year. This extension application was timely received by the Commission, and was date-stamped by the Office of the Secretary on October 20, 2004. The application conformed in virtually all material respects to the extension applications that had previously been granted by the Commission on August 9, 2002 and again on October 21, 2003. To the best knowledge of the University and its undersigned counsel, as of this date the pending application has not been assigned a file number by the Commission.

On April 8, 2008, pursuant to conversations with a member of the Commission's staff in the Media Bureau, and after great expense in assembling the materials involved therein, the University submitted to the Commission a minor amendment to the pending experimental-authorization extension application for the DTS station, consisting of a cover letter from the University's undersigned counsel, an amendment transmittal letter from an officer of the University, a date-stamped copy of the University's October 20, 2004 application for extension, and three reports from the University's outside technical and engineering consultants concerning various field measurements and other operational data pertaining to the DTS station (a copy of

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[10] *See* File No. BPEXT-20010608ABD.

[11] *See* File No. BEPEXT-20020618ABG.

[12] *See* File No. BEPEXT-20030805ARU.

all of the foregoing is attached to this Petition as Exhibit 1). Despite several inquiries by the University's counsel, up to this point in time, the Commission has not taken action upon the University's extension application, as so amended.

Because the Commission has not yet acted upon the University's timely filed and pending extension application, the University's authority to operate the DTS system has not expired. Under Section 307(c)(3) of the Communications Act of 1934, as amended, which provides for the terms of initial and renewal licenses, "[p]ending any administrative or judicial hearing and final decision on such an application and the disposition of any petition for rehearing pursuant to section 405 or section 402, the Commission shall continue such license in effect."[13] In this case, the University timely filed its extension application for its experimental DTS authorization, and supplemented such application. Thus, inasmuch as that extension application remains pending, the University's authority to operate the DTS system in question has not expired.

III. THE RELIEF SOUGHT ON RECONSIDERATION

The University respectfully requests that the Commission issue an *erratum* that corrects footnote 19 of the *Report and Order*. Because the Commission has not acted upon the University's pending extension application, the University's authority to operate its DTS system has not expired. The University requests that footnote 19 be revised to reflect that the University's authority to operate the DTS system has not expired, but rather is still active, and has remained valid since its most recent extension granted on October 21, 2003, pending

[13] 47 U.S.C. § 307(c)(3). In addition, under Section 558(c) of the Administrative Procedures Act, "[w]hen . . . [a] licensee has made timely and sufficient application for a renewal or a new license in accordance with agency rules, a license with reference to an activity of a continuing nature does not expire until the application has been finally determined by the agency." *See* 5 U.S.C. § 558(c).

Commission action on the extension application submitted on October 20, 2004, as amended on April 8, 2008.

Respectfully submitted,

THE PENNSYLVANIA STATE UNIVERSITY

By: ______________________

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Counsel to the Pennsylvania State University

December 31, 2008

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April 8, 2008 25204.74878

BY HAND DELIVERY

Marlene H. Dortch
Secretary
Federal Communications Commission
c/o 236 Massachusetts Avenue, N.E.
Suite 110
Washington, D.C. 20002

Re: Pennsylvania State University's Pending Application for Extension of Experimental Authorization for Distributed-Transmission-System Digital Television Broadcasting Booster Station Serving State College, Pennsylvania, filed on October 20, 2004 (no file number assigned)

Dear Madame Secretary:

We represent The Pennsylvania State University (the "University"), which holds an experimental authorization from the Commission that was originally granted to the University by the Commission on June 26, 2001 (File No. BPEXT-20010608ABD) and was extended on August 9, 2002 (File No. BEPEXT-20020618ABG) and again on October 21, 2003 (File No. BEPEXT-20030805ARU). The experimental authorization permits the University to construct and operate a so-called "distributed-transmission-system" ("DTS") station whose facilities are located at Pine Grove Mills, Pennsylvania. The DTS station serves the community of State College, Pennsylvania by rebroadcasting the signal of the University's primary digital UHF noncommercial, educational television broadcasting station WPSU-DT on Digital Television Channel *15 at Clearfield, Pennsylvania (Facility Identification Number 66219). To the best of our knowledge, the DTS station has not been assigned separate call letters by the Commission.

There is presently pending before the Commission the University's application, submitted on October 20, 2004, that requests the Commission to extend the University's experimental authorization for the DTS station for one (1) additional year. To the best of our knowledge, as of this date the pending application has not been assigned a file number by the Commission.

On behalf of the University, we respectfully submit herewith for filing with the Commission an original and three (3) copies of a minor amendment to the pending experimental-authorization extension application for the DTS station, consisting of a

Paul Hastings

letter to the Commission's Secretary dated April 1, 2008 from Susan J. Wiedemer, the Assistant Treasurer of the University's Board of Trustees, and enclosing several attachments. The attachments to Ms. Wiedemer's letter include a copy of the University's application for extension of the experimental authorization for the DTS station, as filed with and received by the Commission's Secretary on October 20, 2004, as well as certain reports from the University's technical and engineering consultants concerning various field measurements and other operational data pertaining to the DTS station. Among those reports is a statement from The Merrill Weiss Group, LLC of Metuchen, New Jersey, the University's broadcast technical consultant, that is directly responsive to the requirements for submission of an experimental-authorization extension application, as set forth in 47 C.F.R. Section 74.113(a).

In the event that the Commission or its staff should have any questions pertaining to the minor amendment to the University's DTS station experimental-authorization extension application herewith submitted, kindly refer them to the University's undersigned legal and regulatory counsel.

Very truly yours,

John Griffith Johnson, Jr.

John Griffith Johnson, Jr.
of PAUL, HASTINGS, JANOFSKY & WALKER LLP

Enclosures

cc: Kevin Harding, FCC Media Bureau, Video Division
(via first-class mail and electronic mail, with enclosures)

Dr. Walter Sheppard
Program Officer
Public Telecommunications Facilities Program
Room 4812
National Telecommunications and Information Administration
U.S. Department of Commerce
1401 Constitution Avenue, N.W.
Washington, D.C. 20230
(via first-class mail, with enclosures)

bcc (via first-class mail, with enclosures):

Kate Domico, for inclusion in The Pennsylvania State University's local public inspection file in University Park, Pennsylvania for the University's primary digital UHF noncommercial, educational television broadcasting station WPSU-DT, Channel *15, Clearfield, Pennsylvania

S. Merrill Weiss

THE PENNSYLVANIA STATE UNIVERSITY
TELEVISION STATION WPSU-TV/DT
238 Outreach Building
100 Innovation Boulevard
University Park, Pennsylvania 16802-7012

Marlene H. Dortch
Secretary
Federal Communications Commission
The Portals II
445 Twelfth Street, Southwest
Washington, D.C. 20554

Re: Minor Amendment to The Pennsylvania State University's Pending Application for Extension of Experimental Authorization for Distributed-Transmission-System Digital Television Broadcast Booster Station Serving State College, Pennsylvania, filed on October 20, 2004

Dear Madame Secretary:

The Pennsylvania State University (the "University") currently holds an outstanding experimental authorization from the Commission to construct and operate a distributed-transmission-system digital television broadcast booster station that serves the community of State College, Pennsylvania by retransmitting the signal of the University's primary digital UHF noncommercial, educational television station WPSU-DT, Channel *15 in Clearfield, Pennsylvania, via a transmitting facility located in Pine Grove Mills, Pennsylvania and operating on Channel *15. The experimental authorization was most recently extended by the Commission on October 21, 2003 in File No. BEPEXT-20030805ARU.

There is currently pending before the Commission the University's application filed on October 20, 2004 (copy attached) that requests the Commission to extend the experimental authorization for the Pine Grove Mills facility for a further twelve-month period. To the best of the University's knowledge, the October 20, 2004 application has not yet been accepted for filing nor assigned a file number by the Commission.

The purpose of this letter is to submit, as a minor amendment to the application filed on October 20, 2004, the attached documents:

1. " A Report to WPSU-DT, Results of Field Testing of Distributed Transmission System, State College, Pennsylvania," dated December 22, 2007, prepared for the University by the firm of Meintel, Sgrignoli & Wallace of Waldorf, Maryland (" MSW);

2. A letter to the Commission' s Secretary dated February 21, 2008 from the Merrill Weiss Group LLC of Metuchen, New Jersey (" MWG"), the University' s broadcast technical consultants, which provides additional analyis with respect to the MSW Report; and

3. A statement prepared by MWG that specifically addresses the criteria set forth in Section 74.113(a) of the Commission' s Rules for the submission of a supplementary report with an application to extend an experimental broadcast station authorization.

In the event that the Commission or its staff should have any questions concerning this amendment, kindly refer them to the University' s legal and regulatory counsel, as follows:

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Very truly yours,

THE PENNSYLVANIA STATE UNIVERSITY

By: Susan J. Wiedemer

Sue Wiedemer
Assistant Treasurer

Date: April 1, 2008

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October 20, 2004

25204.74878

VIA MESSENGER

RECEIVED

OCT 20 2004

Federal Communications Commission
Office of Secretary

Marlene H. Dortch
Secretary
Federal Communications Commission
236 Massachusetts Avenue, N.E.
Suite 110
Washington, D.C. 20002

Re: Pennsylvania State University's Application for Renewal of Experimental License for Digital Television Booster Station Serving State College, Pennsylvania (File No. BEPEXT-20030805ARU)-

Dear Madame Secretary:

We represent The Pennsylvania State University (the "University"), which holds an experimental license that was originally granted to the University by the Commission on June 26, 2001 (File No. BPEXT-20010608ABD) and renewed on August 9, 2002 (File No. BEPEXT-20020618ABG) and again on October 21, 2003 (File No. BEPEXT-20030805ARU) for the construction and operation of an on-channel UHF noncommercial, educational digital television ("DTV") broadcasting booster station on DTV Channel *15 in State College, Pennsylvania. The booster station is operated in conjunction with the University's primary UHF noncommercial, educational DTV broadcasting station WPSX-DT, DTV Channel *15 in Clearfield, Pennsylvania (Facility Identification Number 66219). The experimental license, as so renewed, is scheduled to expire on October 21, 2004.

Transmitted herewith is a facsimile copy of a letter to the Commission from David F. Marshall, the Assistant Treasurer of the University's Board of Trustees, dated October 19, 2004. Mr. Marshall's letter constitutes the University's application for a further, one-year renewal of the experimental license for the University's DTV booster station serving State College, and provides information responsive to Section 74.113(a) of the Commission's Rules. (The original of Mr. Marshall's letter was inadvertently sent directly to the Commission's offices at 445 Twelfth Street, S.W. in Washington, D.C.)

Also submitted herewith is a "Certification to the Federal Communications Commission," dated October 5, 2004 and executed by Paula R. Ammerman in her capacity as the Director, Office of the Board of Trustees/Associate Secretary on behalf of the University, wherein the University certifies to the Commission that neither the University, nor any officer or member of the Board of Trustees, is subject to the denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988.

Inasmuch as the University operates the DTV booster station in State College on a noncommercial, educational basis in conjunction with the noncommercial, educational broadcast service provided by WPSX-DT, no filing fee is required to be paid to the Commission in connection with this application, pursuant to Section 1.1114(d) of the Commission's Rules.

In the event that the Commission or its staff should have any questions with respect to this matter, kindly refer them to the University's undersigned counsel.

Very truly yours,

John Griffith Johnson, Jr.

John Griffith Johnson, Jr.
of PAUL, HASTINGS, JANOFSKY & WALKER LLP

Enclosures

Penn State Public Broadcasting
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October 19, 2004

Marlene H. Dortch
Secretary
Federal Communications Commission
The Portals II
445 Twelfth Street, S.W.
Washington, D.C. 20554

Re: The Pennsylvania State University's ("PSU's") Application to the Federal Communications Commission (the "FCC") Requesting the Renewal by the FCC of PSU's Outstanding Experimental Authorization (the "Authorization") for a Digital UHF Noncommercial, Educational Television Broadcasting Booster Station (the "Booster Station") at Pine Grove Mills, Pennsylvania, Serving the Community of State College, Pennsylvania (File No. BEEXP-20030805ARU)

Dear Ms. Dortch:

This letter is being submitted to the FCC on behalf of PSU and constitutes PSU's application referenced above (the "Application"). PSU's currently-outstanding Authorization (File No. BEEXP-20030805ARU) is currently due to expire on October 21, 2004.

In support of this Application, PSU offers the following, which tracks the provisions of 47 C.F.R. Section 74.113(a):

(1) Number of hours operated: For approximately the past six months, the Booster Station has been operating for 24 hours per day, seven days per week. Prior to that point in time, operation over the previous year was intermittent while system problems were encountered and resolved (as more fully described in this letter).

(2) Data on research and experimentation (including types of transmitting and studio equipment used and their mode of operation): The normal complement of equipment for distributed transmission is and has been in place, including a distributed transmission adapter at the studio, which is locked to the Global Positioning System ("GPS") in order to provide precision timing information for the exciters at the locations of the transmitters of both the primary digital television station (WPSX-DT in Clearfield, Pennsylvania) and the Booster Station in Pine Grove Mills, Pennsylvania. The exciters have been specially modified to accept the timing information. The Booster Station transmitter is an Axcera, Model DT-LDU1A-4, employing a DT2B modulator, which is also locked to GPS in order to provide a stable frequency reference and timing reference for the incoming digital stream.

During the early part of the past year, some preliminary tests were accomplished for the purpose of determining the viability of distributed transmission. [1] These tests consisted of taking measurements at various test locations where the signals from both the primary digital station transmitter (WPSX-DT) and the Booster Station transmitter were available, and adjusting the timing on the exciter at the Booster Station in order to bring the digital symbols emanating from the two transmitting locations within the correction range of the adaptive equalizer of the test receivers. The four different receivers that were used all had varying tolerances to the echo generated by the simultaneous transmission from the two transmitters that constitute the distributed transmission system ("DTS"). The system worked, but was not stable because of excessive data stream drift on the microwave studio-to-transmitter link ("STL"). In order to correct this problem, the transmitter manufacturer – Axcera – is redesigning the DTS adapter at the studio and the transmitter exciters so that they will be able to accommodate the higher data drift rate which would be typical of a microwave STL, and the STL manufacturer is making changes to further reduced the system drift rate. These revisions are currently ongoing.

(3) Data on expense of research and operation during the period covered: These data are not currently available.

(4) Power employed, field-intensity measurements, and visual and aural observations, and the types of instruments and receivers utilized: The Booster Station transmitter is currently running with an effective radiated power of 48 kiloWatts (or 16.8 dBk). The following devices have been used to conduct the tests described above:

Corner Reflector Yagi (manufactured by Radio Shack)
Set-top UHF bow-tie antenna (manufacturer unknown)
Spectrum analyzer – Agilent Technologies Model 4405B
Test receiver – Rohde & Schwartz Model EFA
Integrated receiver/decoder – Sencore IRD 3384
Set-top converter – Zenith Model HDV-420
Set-top converter – Panasonic Model TU-DST50W

The main purpose of the testing thus far has been to determine the compatibility of different receiving devices with the DTS signal under varying desired-to-undesired ("D/U") signal ratios and different timing between the D/U signals. This was accomplished using various mountaintop locations, where the signal levels would most likely be nearly equal. The data stream rate stability problem described earlier caused the results to be deemed inconclusive, and further testing has been temporarily suspended pending resolution of the microwave and the timing element issues by Axcera and by the STL equipment manufacturer.

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[1] *See Report and Order in MB Docket No. 03-15, RM-9832, Second Periodic Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television,* FCC 04-192, adopted on August 4, 2004 and released on September 7, 2004, 19 FCC Rcd ____, 69 Fed. Reg. 59500 (published October 4, 2004), at Para. 176 and n. 413.

(5) Estimated degree of public participation in reception: Due to the technical difficulties experienced, as explained above, PSU has not yet been in a position to involve the viewing public in the operations of the Booster Station.

(6) Conclusions (tentative and final): In view of the technical problems encountered, PSU will need additional time in which to work out those problems and conduct additional tests from which meaningful data can be assembled that will support conclusions. [2]

(7) Program of further developments in broadcasting: This program will be developed once the technical issues that have been described in the earlier portions of this letter shall have been resolved.

(8) All developments and major changes in equipment: Apart from what has already been reported in this letter, there are no further developments or changes in equipment to report.

(9) Any other pertinent developments: The only additional pertinent development appears to be the FCC's issuance of its *Report and Order*, footnote 1, *supra*, in which the FCC indicated that it will soon launch a new rule making proceeding for the purpose of developing service rules for DTS, and in the meantime will entertain requests for authorizations on a case-by-case basis to experiment with DTS. PSU respectfully submits that by renewing the Authorization, the FCC can advance that program and enable PSU to resolve the technical problems that have been encountered to date, so that additional operational data that may be of use to the FCC in its DTS rule making proceeding can be assembled and submitted.

Attached to this letter is an Anti-Drug Abuse Act Certification to the FCC on behalf of PSU and its Board of Trustees, executed as of October 5, 2004.

Because the Booster Station is operated as a noncommercial, educational station in conjunction with the operations of PSU's primary digital noncommercial, educational television broadcast station WPSX-DT in Clearfield, Pennsylvania, this Application is exempt from the requirement that PSU pay an application filing fee to the Commission, in accordance with 47 C.F.R. Section 1.1114(d).

In the event that the FCC should have any questions with respect to this Application, please refer them to PSU's regulatory counsel in this matter, as follows:

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[2] *See Report and Order*, footnote 1, *supra*, at Para. 178 ("We note that the record in this proceeding does not reflect current successful and practical operation of DTS technology. We will authorize additional experimentation and development work . . . .").

Very truly yours,

David F. Marshall

Signature

DAVID F. MARSHALL
ASSISTANT TREASURER

Print or Type Name

Title

Date: October 19, 2004

PENNSTATE

Board of Trustees

The Pennsylvania State University
205 Old Main
University Park, PA 16802-1571

814-865-2521
Fax: 814-863-4631

CERTIFICATION TO THE FEDERAL COMMUNICATIONS COMMISSION

The Pennsylvania State University hereby certifies to the Federal Communications Commission that neither The Pennsylvania State University, nor any officer or member of the Board of Trustees of The Pennsylvania State University is subject to denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988. [Section 5301 provides, in substance, that any person convicted of any federal or state offense consisting of the distribution of a controlled substance may, as part of the sentence, be denied federal benefits, such as an FCC license.]

The Pennsylvania State University

By: Paula R. Ammerman
Name: Paula R. Ammerman

Title: Director, Office of the Board of Trustees/
Associate Secretary

Date: October 5, 2004

A Report to
WPSU-DT
Results of Field Testing of
Distributed Transmission System
State College, Pennsylvania

December 22, 2007

Meintel, Sgrignoli, & Wallace

1282 Smallwood Drive
Suite 372
Waldorf, Maryland 20603
(202) 251-7589

WPSU DISTRIBUTED TRANSMISSION FIELD TEST REPORT

Background

Distributed transmission (**DTx**) is a means by which multiple *synchronized* transmitters on the same channel form a single frequency network (**SFN**) and jointly cover a larger service area than can a single transmitter. The digital television (**DTV**) signals from the various transmitters overlap, but a DTV receiver can take advantage of this fact since these signals are precisely *synchronized* in carrier frequency, symbol clock, symbol modulation, and relative timing. When two or more of these signals reach a DTV receiver, they act like multipath (i.e., delayed signal echoes) rather than co-channel DTV interference. While a co-channel DTV-into-DTV desired-to-undesired (**D/U**) interference ratio of only 15 dB can be handled by a DTV receiver, much stronger levels of interference from synchronized DTV signals, down to 0 dB, can be handled. With the advent of 5[th] generation (**5G**) DTV receiver equalizer performance, DTx is now feasible for enhancing and extending DTV service in areas previously unreachable with single transmitters. The additional synchronized transmitters, called "gap fillers," are considered distributed transmitters (**DTxTs**), and are relatively lower power units that fill-in small hard-to-reach population centers using lower values of effective radiated power (**ERP**).

The Pennsylvania State University, licensee of public television station WPSU-TV (formerly **WPSX-TV**), currently transmits an analog NTSC signal on VHF Channel 3. WPSU has unique terrain and geographic challenges in its area due to various mountains and valleys. The low-frequency VHF signal is able to diffract over the main obstruction (Rattlesnake Mountain) to provide television coverage to viewers in the valleys where the population centers are situated. The predicted coverage and service area of the paired DTV station on UHF Channel 15 is considerably smaller, however, since UHF signals do not "bend" nearly as much as the low-frequency VHF signals. Therefore, viewers in the population centers of State College, Altoona, and Johnstown are not be able to receive WPSU's DTV signal. No matter where a main high-power DTV transmitter might be located, there always would be some large population center that would not be served due to the major cities being located in isolated valleys separated by mountain ridges. Raising the transmit antenna high enough to overcome the terrain obstacles (by quadrupling the tower height) at the current main transmitter site was *not* an option due to FAA restrictions. The tower height nevertheless was doubled.

Therefore, the DTx system was selected to resolve the problem of filling in the "city valleys" with a *synchronized* DTV signal. The master WPSU DTS design, created by the Merrill Weiss Group LLC (**MWG**) and based on the ATSC A/110A standard that is part of the ATSC DTV standard, involves four synchronized transmitters on Channel 15 strategically placed throughout the desired coverage area so that all the major cities would have enough DTV signal strength for indoor set top box (**STB**) reception. The system *design* calls for one of the DTxTs to be a high power (810 kWatts ERP) main unit located in Clearfield PA while the other three DTxTs are moderate power (25 – 50 kWatts, ERP). Any coverage areas with significant overlap were located in sparsely populated areas so that minimal interference effects would be experienced.

In order to alleviate the terrain-shielding problem, WPSU has *initially* deployed a distributed transmission system (**DTS**) on UHF Channel 15 for its digital television (**DTV**) station WPSU-DT. This was the first DTx system implemented in the United States, beginning broadcast operations in July 2003.In the initial deployment of this DTS, however, only two transmitters have been constructed.

The first is the high-power "main" distributed transmitter co-located with the analog CH 3 transmitter at the Clearfield transmitter site, with a height of 950.6 meters above mean sea level (**AMSL**) and a height above average terrain (**HAAT**) of 413.6 meters. It is operating at 540 kW ERP, operating on a Special Temporary Authorization (**STA**) at only two-thirds power due to Canadian coordination issues still to be resolved by the FCC.

The second is a lower-power "distributed" transmitter at Pine Grove Mills, PA, near State College, PA, with a height of 674.8 meters AMSL (301.5 meters HAAT). While it has a 50 kW ERP authorization, it is only transmitting 48 kW, ERP.

Figure 1 contains a *map* of the general area that illustrates the location of the two DTS transmitters in relation to State College. This implementation provides a test bed for development of DTx and its associated technology as well as an opportunity for further understanding and insight into ATSC single frequency networks that use 8-VSB transmission.

Project Goals and Objectives

At the beginning of the project, the ultimate goal was to determine the *general* impact of distributed transmission on overall DTV service in State College using recent-generation DTV receivers as well as the *specific* impact of the DTx transmitter at

Pine Grove. In order to determine the effectiveness of the initial system deployment, WPSU decided to make field measurements of the DTV signals from *both* facilities to assess the increase or decrease of DTV Service in specific geographical areas. Additionally, since the DTS system is currently being operated pursuant to an FCC experimental license, WPSU is required to provide certain measurements and reports to the FCC in order to finalize the facilities licensing.

To satisfy the requirement for the FCC DTS performance report, WPSU chose to gather transmitter field strengths from its main Clearfield transmitter as well as "composite" transmitter signal field strengths when both transmitters (Clearfield and Pine Grove) were simultaneously operating. DTV service measurements using two recent-generation DTV receivers also were planned in order to determine the robustness of DTV reception with and without DTx active.

The firm of Meintel, Sgrignoli, & Wallace, LLC (**MSW**) was requested to provide a proposal for the field measurement program in the greater State College, PA area for WPSU-DT, and subsequently was awarded the contract. The field test was performed between **July 12, 2007** and **September 13, 2007**.

Field Test Vehicle Design

The WPSU field test vehicle (donated by Cox Broadcasting Station KTVU) was a 1993 E-350 Ford Econoline van with a 4.5 kWatt generator and a pneumatic mast extendable to at least 30 feet above ground level (**AGL**).

For the 30-foot AGL measurements, there was a remote-controlled rotator at the top of the mast that allowed the operator to point the antenna in any direction (over a 360 degree range) from within the field test truck. A *photograph* of the vehicle is shown in **Figure 2a** at a measurement site with its mast extended to 30-feet AGL.

Measurements at 6 feet AGL were performed by removing the rotator assembly from the mast and placing it into a fixture that allowed it to be placed on the ground up to 20 feet from the truck in a vertical position, as shown in **Figure 2b.** Once again, the rotator is controlled from within the field test vehicle.

Figure 3 illustrates the *block diagram* of the receiving system hardware associated with the field test vehicle, including antenna, preamplifier, coaxial feedline, splitter, test equipment, and DTV receivers. The receiving system hardware is described as follows:

The outdoor antenna was a 10-element, 6-channel commercial Yagi antenna from Blonder Tongue (Model BTY-10). This 75-Ohm antenna, which was cut for 470 – 506 MHz (CH 14-19) had 9.5 dBd of gain (at CH 15), a total beamwidth of 46 degrees, and a front-to-back ratio of 21 dB. The indoor antenna was a 75-Ohm UHF log periodic design from Zenith (Model # ZHDTV1) with a gain of 3.2 dBd, an approximate total beamwidth of 69 degrees, and a front-to-back (major-to-minor lobe) ratio of about 3.6 dB. Both of these antennas were measured on an antenna range prior to the start of field testing.

A *single*-channel 75-Ohm low-noise preamplifier (Blonder Tongue SCMA-Ub) was situated at the top of the antenna mast with an external 3-dB pad at its input for matching purposes. This preamplifier had about 26 dB of gain at CH 15 and a 2.5 dB noise figure, and was powered through the coaxial feedline from inside the field test vehicle. The built-in band pass filter (±0.75 dB flatness) at the input protected the preamplifier from overload due to any strong interference signals that might be present during field testing.

The preamplifier fed a 75-Ohm double-shielded RG-6 (Belden # 9248) coaxial cable followed by a 4-way splitter. The splitter outputs were connected to an Agilent E4405B spectrum analyzer (SN MY41440299), an ETRI TxID Watermark processor, and two 5th generation set-top boxes (**STBs**). The two 5G receivers are referred to as Receiver #1 (**Rx #1**) and Receiver #2 (**Rx #2**).

The net system gain from the antenna output (i.e., the input to the preamplifier) to the spectrum analyzer input was measured and found to be 15.9 dB. This system gain value, along with the appropriate antenna gain (either Yagi outdoor or log periodic indoor) and CH 15 dipole factor (128.75 dBm-dBµV/m), were used for all field strength calculations in the related Excel spreadsheets.

Two 5G STB units were employed in this DTS field test. The first unit (Rx #1) was a prototype of an NTIA coupon-eligible D/A converter that will be available in the first quarter of 2008 while the second unit was a production model currently available at retail. Both of these units were laboratory verified for performance, with the following results:

DTV Rx #1	Equalizer Mask Range:	-74 to +74 µsecs
	Paired Echo Range:	-27 to +28 µsecs
DTV Rx #2	Equalizer Mask Range:	-25 to +59 µsecs
	Paired Echo Range:	-12 to +13 µsecs

Field Test Locations

The measurement program completed by MSW consisted of 108 outdoor sites with the receiving antenna at 30 feet AGL and 21 outdoor sites with the receiving antenna at 6 feet AGL. Additionally, three special sites were tested that exhibited particular features. The measurement test sites were broken down into 4 radials and 3 grids, and were based on appropriate areas of population within the valley.

The test sites can be described as follows.

1. Grid #1: This grid was in the State College, PA. area, and consisted of 20 measurement locations using a receiving antenna at 30 feet AGL.
2. Grid #2: This grid was in the Bellefonte, PA. area, and consisted of 20 measurement locations using a receiving antenna at 30 feet AGL.
3. Grid #3: This grid was in the Pleasant Gap, PA area, and consisted of 20 measurement locations using a receiving antenna at 30 feet AGL.
4. Radials: Four radials extended from the Pine Grove Mills gap filler transmitter site at bearings of interest toward the State College, PA area. The radials extended from the transmitter to a distance of between 13.4 and 16.3 miles. Radial 1 and Radial 2 *each* had 12 measurement locations while Radial 3 had 10 measurement locations and Radial 4 had 11 measurement locations, for a total of 45 radial measurement locations.
5. Special: Three special test locations were measured at 30 feet AGL, each having particular features. These sites were measured to verify the correct timing of the system and were located in areas of known signal conditions.
6. Set-Top Height Measurements: Within *each* of the three Grids, 7 measurement sites were visited to perform "set-top height" measurements for a total of 21 test locations. These measurements were made *outdoors* using an indoor Silver Sensor antenna that was approximately 6 feet AGL.

In summary, there were a total of 108 thirty-foot test locations that were measured, which included 45 radial sites, 60 grid sites, and 3 special sites. Additionally, a total of 21 six-foot test locations were measured, but only within the three grids. These test sites were defined by MWG and the WPSU staff prior to the start of the measurement program, and are illustrated in **Figure 1** along with the transmitter locations.

Field Test Methodology

The test procedure was as follows:

1. Plot test locations on topographic maps and road maps to identify roads providing a reasonable match to the measurement sites and objectives.
2. At the start of the day, confirm proper operation of the two transmitters and field test van equipment. (Morning Calibration Tests).
3. At each measurement location perform the following:

   a. Confirm feasibility of raising antenna to 30 feet AGL without encountering obstructions such as trees or overhead wires.

   b. If location is not suitable, move to *closest* suitable location, and place traffic cones to warn passing motorists.

   c. With antenna in place and connected, raise antenna to 30 feet AGL height.

   d. Determine GPS coordinates of location as well as distance and bearing to *each* distributed transmitter, plot terrain profiles from transmitter to measurement location.

   e. Describe test site and document weather conditions. Take picture of field test van to document measurement location and antenna orientation.

   f. Measure the receiving circuit's average noise floor power (in 6 MHz) in the truck.

   g. Using spectrum analyzer, orient antenna for *maximum* DTV signal strength with *only* the Clearfield Transmitter ON, and document the antenna bearing relative to true north.

   h. Measure and record average DTV signal power (in 6 MHz) with the spectrum analyzer.

i. *Calculate* the RMS DTV field strength (in 6 MHz) using the truck's system gain, antenna gain, and CH 15 dipole factor.

j. *Calculate* and document the carrier to noise (**CNR**) ratio of the signal through the truck's receiving system.

k. Record (save on disk and plot hard copy) 20 MHz wide spectrum at 10 dB/div. (stop band). Note any co-channel or adjacent channel interference (analog or digital) that appears to be present.

l. By continuous observation, note and document the number of "hits" in the DTV reception for each DTV receiver during a *three-minute* period.

m. Using the ETRI TxID unit, record channel distortion and save Echo Profiles on disk.

n. Rotate antenna 360 degrees, recording the ranges for which DTV reception is possible for each DTV receiver, and record up to 6 good segments. Record the number of degrees of rotation in each good segment as well as the net total number of degrees that represent successful DTV reception.

o. Document comments relative to any anomalous observations.

p. Change the transmitter configuration as required for next data set (*both* Clearfield and Pine Grove transmitters ON).

q. Repeat steps (g) through (o) with both transmitters ON.

r. Verify that all data is properly documented, and make backup of all electronic data (spectrum analyzer plots, TxID files, spreadsheet files, etc.).

s. Lower antenna, prepare vehicle for travel, and proceed to next measurement location.

Field Test Results

The analysis of the WPSU field data can be broken up into several components, such as DTV field strength, DTV service, and DTV antenna adjustment range. Additionally, the 6 foot AGL measurements allow the difference in field strength between the 30-foot and 6-foot AGL receiving antenna heights to be evaluated.

DTV FIELD STRENGTH

The primary purpose of the additional "gap filler" transmitters is to provide CH 15 DTV signals in valleys around the State College area that cannot be reached by the WPSU main transmitter due to terrain obstructions. Of course, since the areas of interest are not *all* isolated from the main Clearfield transmitter (i.e., there are some coverage areas that were overlapped by both transmitters); the two DTV transmitters are synchronized for optimum DTV reception and maximum service area. Therefore, a comparison of signal strength with and without an active gap filler transmitter is warranted, along with the respective Signal-to-Noise ratio (**SNR**) calculations. Note that the SNR value at any given site must be at least 15 dB (even larger when multipath distortion or signal interference is present) to be above the threshold of visible errors (**TOV**) and the threshold of audible errors (**TOA**).

At the 30-foot AGL receiving antenna height, the median DTV field strength at 108 test sites was 44.0 dBμV/m when only the main Clearfield transmitter was active, which produced a <u>median</u> SNR value of only 22.8 dB. This resulted in 90 sites (83.3%) of the 108 test sites with an SNR value *greater* than the 15 dB value required for successful DTV reception. When the synchronized gap filler in Pine Grove was active, however, the <u>median</u> field strength significantly *increased* to 76.8 dBμV/m, with a median SNR value of 55.9 dB. This resulted in all of the 108 test sites (100%) having an SNR value *greater* than the required 15 dB value. This significant increase of field strength (and related SNR) over the desired coverage area allows for the *possibility* of improved WPSU DTV service on CH 15 at typical <u>outdoor</u> receiving antenna heights, assuming any DTS multipath that occurs does not preclude reception. For a better visual description of this situation, **Figure 4** contains a probability density function (**PDF**) of the field strengths measured at all 108 sites with and without DTx, while **Figure 5** contains the related complementary cumulative distribution function (**CCDF**). The percentage of accumulated sites for every measured field strength value is significantly larger for DTx active than DTx inactive, demonstrating the trend towards significant increase in field strength.

A similar analysis at the 6-foot AGL receiving antenna height is also beneficial. With a much lower receiving antenna height of 6 feet AGL, it is expected that the DTV field strength will be found statistically much lower than that found at 30 feet AGL. The median DTV field strength at 21 sites was a very low 34.2 dBμV/m when only the main Clearfield transmitter was active, which produced a <u>median</u> SNR value of only 6.9 dB (a value *below* TOV). This resulted in only 4 of the 21 test sites (19.0%) with an SNR value *greater* than the required 15 dB value for successful DTV reception. When the synchronized gap filler in Pine Grove was active, however, the <u>median</u> field strength *increased* to 56.2 dBμV/m, with a median SNR value of 35.2 dB. This resulted in 19 of the 21 test sites (90.5%) having an SNR value *greater* than the required 15 dB value. This significant increase of field strength over the desired coverage area allows for the *possibility* of improved WPSU DTV indoor service on CH 15 at lower receiving antenna heights. Of course, these 6-foot AGL field tests were conducted outdoors, accounting only for the typical decrease in signal strength with lower receiving antenna height and *not* for building attenuation. The median 35.2 SNR value will allow for up to 20 dB of building penetration loss. For a better visual description of this situation, **Figure 6** contains a PDF of the field strengths measured at all 21 sites with and without DTx, while **Figure 7** contains the related CCDF. Again the trend towards significant increase in field strength is also obvious in these figures.

While there is no doubt that the Pine Grove gap filler transmitter significantly *increased* the field strength (i.e., *coverage*) in most locations for both the 30-foot AGL (107 of the 108 sites, or 99.1%) and 6-foot AGL (18 of the 21 sites, or 85.7%) receiving antenna heights, the next most important question is whether the gap filler provided a net increase in *service* area for WPSU-DT.

Before evaluating DTV service, however, one other means of analysis is to look at the number of test sites that had a received SNR above some "safe" value, such as 20 dB. This SNR level provides margin for DTV receivers to deal with severe multipath conditions that may require several dB of increased signal level to overcome the noise enhancement that naturally occurs in a DTV receiver's equalizer. The percentage of test sites with an SNR value of 20 dB or more increased with DTx active from 66.7% to 100% with 30-foot AGL reception and increased from 14.3% to 81.0% with 6-foot AGL reception.

A summary of the field strength and SNR analysis is contained within **Table 1**. While coverage analysis, which involves sufficient field strength and resulting SNR values, is a necessary condition for analyzing the effect of DTx, it is not sufficient for complete DTV service evaluation. It is necessary to analyze DTV service by measuring the *actual* DTV reception capability at each test site for both of the two 5G test receivers.

Table 1 Field strength and SNR analysis for both 30-foot AGL and 6-foot AGL reception.

Reception Condition (Antenna Height)	Test Parameter Description	Total # of Test Sites	Clearfield Only (No DTx)	Clearfield & Pine Grove (With DTx)
30 ft AGL	Median Field Strength	108	44.0 dBµV/m	76.8 dBµV/m
30 ft AGL	Median SNR	108	22.8 dB	55.9 dB
30 ft AGL	# of Sites above 15 dB SNR	108	90 (83.3%)	108 (100%)
30 ft AGL	# of Sites above 20 dB SNR	108	72 (66.7%)	108 (100%)
6 ft AGL	Median Field Strength	21	34.2 dBµV/m	56.2 dBµV/m
6 ft AGL	Median SNR	21	6.9 dB	35.2 dB
6 ft AGL	# of Sites above 15 dB SNR	21	4 (19.0%)	19 (90.5%)
6 ft AGL	# of Sites above 20 dB SNR	21	3 (14.3%)	17 (81.0%)

DTV SERVICE

For this part of the field test, the receiving antenna (at either 30 feet AGL or 6 feet AGL) was adjusted (i.e., "peaked") to provide a maximum DTV signal level at the input to the receivers. DTV service was defined as 3 "hits" or fewer during a 3-minute viewing time interval. If there were only 3 video interruptions or fewer, the location was deemed as a successful reception site under the given transmission conditions. Since DTV service was determined for both conditions (with active DTx and with active DTx), a comparison can be drawn as to any WPSU-DT service improvement or degradation caused by the DTx network.

At the 30-foot AGL receive antenna height, DTV service existed *without* DTx at 55 out of the 108 sites (50.9%) for **Receiver #1** and 56 out of the 108 sites (51.9%) for **Receiver #2**. Therefore, DTV service was about 50% when only the Clearfield transmitter radiated the DTV signal. Approximately 17% of the 108 sites had too weak a signal (i.e., received SNR < 15 dB), which explains these site failures. Expanding the analysis beyond sites that had 15 dB SNR or less, a total of 33.3% of the sites had less than 20 dB SNR values, which *may* explain additional failures since more signal level (i.e., a higher SNR value) is required in the presence of severe multipath (either naturally occurring or DTS-induced). The remaining sites that failed had more than enough signal level, so either multipath or interference (or both) were to blame.

When the Pine Grove gap filler transmitter was also radiating a synchronized DTV signal, however, DTV service at 30 feet AGL was observed at 95 of the 108 sites (88.0%) for **Receiver #1** and 94 out of the 108 sites (87.0%) for **Receiver #2**, which is a significant increase. Since all the test sites had more than enough signal level, the small percentage of sites that had no DTV reception failed due to either multipath or interference (or both). Of the 13 (**Receiver #1**) or 14 (**Receiver #2**) failed sites, some were obviously caused by long multipath created by the DTx system. Here are some *examples* of strong (> -18 dBc), long (> 40 μsecs pre- or post-echo) multipath conditions that were observed at some of the test sites, and which probably were the main causes of failed DTV reception at these sites:

-14.2 dBc @ -41.2usec

-23.3 dBc @ +54.2 usec

-17.2 dBc @ +117.8 usec

-16.6 dBc @ +120.1 usec

-17.0 dBc @ +137.2 usec

Despite the relatively few *self*-induced multipath failures, however, 46.3% of the 108 sites had improved DTV service with **Receiver #1**, while 45.4% of the 108 sites had improved DTV service with **Receiver #2**. On the other hand, **Receiver #1** (9.3%) and **Receiver #2** (10.2%) each experienced a small amount of *degraded* DTV service because of the active DTx system. This leaves a net *improvement* increase of 37.0% (40/108) for **Receiver #1** and 35.2% (38/108) for **Receiver #2**. In other words, over one-third of the 108 test sites showed DTV service *improvement* when using the DTx system in State College with 5G DTV receivers.

At the 6-foot AGL receive antenna height, DTV service existed without DTx at only 3 out of the 21 sites (14.3%) for **Receiver #1** and 4 out of the 21 sites (19.0%) for **Receiver #2**. Therefore, DTV service was only about 15% to 20% when only the Clearfield transmitter radiated the DTV signal. Approximately 81% of the sites had weak signals, which easily explains why only 19% of the 21 sites had DTV service. The 3 or 4 sites that had enough received signal level had DTV reception.

When the Pine Grove gap filler transmitter also was radiating a synchronized DTV signal, however, DTV service was observed at 16 of the 21 sites (76.2%) for **Receiver #1** and 15 out of the 21 sites (71.4%) for **Receiver #2**, which is a significant increase. Only 2 sites failed due to weak signal (SNR<15 dB), with an additional 2 perhaps failing due to SNR values less than 20 dB. Therefore, 14 of the 21 test sites had improved DTV service with **Receiver #1** while 12 of the 21 had improved DTV service with **Receiver #2**. Each receiver only had 1 site (G2-05) with degraded DTV receiver performance, and the reason for the loss of service at this one site was likely due to the presence of a very long, strong pre-echo (-17 dB @ -32 usec) combined with a low SNR (22 dB). Likewise, **Receiver #2** had intermittent reception problems (Site G1-04) due to the presence of a strong, long echo (-17.7 dB @ +66.9 usecs). It also should be noted that DTx significantly helped DTV reception in Grid 1 and Grid 3, but 4 of the 7 Grid 2 test sites failed with DTx active. In that same Grid 2, however, 5 of the 7 test sites failed without DTx active. In other words, the DTX system did *not* hurt DTV reception within Grid 2, but it did not help it much either.

Table 2 contains a summary of the DTV service analysis. Note the similar performance for *both* DTV receivers utilized in these field tests.

Table 2 DTV service for 30-foot AGL and 6-foot AGL reception.

Reception Condition (Antenna Height)	Test Parameter Description	Total # of Test Sites	Clearfield Only Transmitter (No DTx)		Clearfield & Pine Grove Transmitters (With DTx)	
-----	-----	—	Rx #1	Rx #2	Rx #1	Rx #2
30 ft AGL	DTV Service w/o DTx	108	55 (50.9%)	56 (51.9%)	95 (88.0%)	94 (87.0%)
30 ft AGL	Improved Reception	108	-----	-----	50 (46.3%)	49 (45.4%)
30 ft AGL	Degraded Reception	108	-----	-----	10 (9.3%)	11 (10.2%)
30 ft AGL	*Net* Improvement	108	-----	-----	40 (37.0%)	38 (35.2%)
6 ft AGL	DTV Service w/o DTx	21	3 (14.3 %)	4 (19.0%)	16 (76.2%)	15 (71.4%)
6 ft AGL	Improved Reception	21	-----	-----	14 (66.7%)	12 (57.1%)
6 ft AGL	Degraded Reception	21	-----	-----	1 (4.8%)	1 (4.8%)
6 ft AGL	*Net* Improvement	21	-----	-----	13 (61.9%)	11 (52.4%)

DTV ANTENNA ADJUSTMENT RANGE

Another aspect in determining the effects of DTx on DTV service is *ease* of antenna adjustment, whether describing a situation with an outdoor rooftop antenna, an attic antenna, or an indoor antenna. Since the field test plan called for rotating the receiving antenna around a 360-degree range and noting sectors of DTV service, some analysis of antenna adjustment range can be performed. This antenna ranging was performed separately for both DTV receivers as well as separately for the cases of DTx active and DTx inactive. This provides an opportunity to compare antenna adjustment results, and therefore determine any positive or negative effects caused by the DTx system.

The median 30-foot AGL outdoor antenna adjustment range for the 108 test sites when using **Receiver #1** was only 41.0 degrees when DTx was inactive (i.e., only the Clearfield transmitter radiating a DTV signal), while the antenna range jumped significantly to 275.0 degrees for **Receiver #1** when DTx was active (i.e., both Clearfield and Pine Grove transmitters radiating a DTV signal). For **Receiver #2**, the results were 40.5 degrees of adjustment range with DTx inactive and 259.0 degrees with DTx active. Both 5G DTV receivers experienced a much larger adjustment range with active DTx, which means that less critical antenna adjustment is necessary by the viewer. This is an important factor, especially in areas where multiple DTV stations are located in different directions from a viewer's residence.

With the receiving antenna at 30 feet AGL and with DTx *inactive*, there were only 21 sites that had at least two separate sectors of DTV reception and only 3 sites that provided three separate sectors (maximum). On the other hand, when DTx was active with 30-foot AGL reception, there were 35 sites that had at least two separate sectors of DTV reception, 10 sites that had at least three separate sectors, and 1 site that had four separate sectors. Therefore, there is more opportunity to successfully receive DTV signals with an outdoor antenna when DTx is utilized.

With the receiving antenna at 6 feet AGL and with DTx *inactive*, there were no sites for either receiver that had more than one separate sector of DTV reception. On the other hand, when DTx was activated with 6-foot AGL reception, there were 3 sites with **Receiver #1** and 4 sites with **Receiver #2** that had two separate sectors of DTV reception. Therefore, there is more opportunity to successfully receive DTV signals with indoor antennas when DTx is utilized.

Table 3 contains the data results for the adjustment range analysis. Once again, note the similar performance for both **Receiver #1** and **Receiver #2** utilized in these field tests.

Table 3a Antenna Adjustment Range for 30-foot AGL reception for each DTV receiver.

Test Parameter	Total # Of Test Sites	Clearfield Only (No DTx)		Clearfield & Pine Grove (With DTx)	
-----	-----	Rx #1	Rx #2	Rx #1	Rx #2
# of total sites	108	108 (100%)	108 (100%)	108 (100%)	108 (100%)
# of failed sites	108	45 (41,7%)	46 (42.6%)	7 (6.5%)	10 (9.3%)
# of good sites with range > 0 deg	108	63 (58.3%)	62 (57.4%)	101 (93.5%)	98 (90.7%)
# of good sites with range > 45 deg	108	49 (45.4%)	52 (48.1%)	97 (89.8%)	96 (88.9%)
# of good sites with range > 90 deg	108	24 (22.2%)	18 (16.7%)	88 (81.5%)	82 (75.9%)
Median adjustment range (for good sites)	108	72.0 deg	70.0 deg	297.0 deg	289.5 deg
# of sites with ***improved*** range > 0 deg	108	-----	-----	86 (79.6%)	88 (81.5%)
# of sites with ***improved*** range > 45 deg	108	-----	-----	81 (75.0%)	81 (75.0%)
# of sites with ***improved*** range > 90 deg	108	-----	-----	78 (72.2%)	74 (68.5%)

Table 3b Antenna Adjustment Range for 6-foot AGL reception for each DTV receiver.

Test Parameter	Total # Of Test Sites	Clearfield Only (No DTx)		Clearfield & Pine Grove (With DTx)	
-----	-----	Rx #1	Rx #2	Rx #1	Rx #2
# of total test sites	21	21 (100%)	21 (100%)	21 (100%)	21 (100%)
# of failed test sites	21	18 (85.7%)	17 (81.0%)	6 (28.6%)	7 (33.3%)
# of good test sites with range > 0 deg	21	3 (14.3%)	4 (19.0%)	15 (71.4%)	14 (66.7%)
# of good test sites with range > 45 deg	21	2 (9.5%)	3 (14.3%)	14 (66.7%)	14 (66.7%)
# of good test sites with range > 90 deg	21	2 (9.5%)	2 (9.5%)	14 (66.7%)	12 (57.1%)
Median Adjustment Range (for good sites)	21	108.0 deg	84.0 deg	351.0 deg	355.5 deg
# of sites with ***improved*** range > 0 deg	21	-----	-----	14 (66.7%)	13 (61.9%)
# of sites with ***improved*** range > 45 deg	21	-----	-----	14 (66.7%)	13 (61.9%)
# of sites with ***improved*** range > 90 deg	21	-----	-----	14 (66.7%)	12 (57.1%)

The reasons for DTV reception failure are important to understand when *rotating* the receiving antenna during antenna ranging. Reduced signal level often occurs due to the directionality of the antenna (i.e., front-to-back ratio) as it is rotated away from a strong desired DTV signal source. However, this effect is lessened when DTx is active since signal levels tend to be stronger and can overcome the extra attenuation on the sides and backside of the antenna. In some cases with DTx active, the antenna can be rotated 360 degrees while maintaining DTV reception because of both stronger signal levels and robust multipath equalization. Likewise, as the *desired* signal gets weaker, both multipath and interference can increase. The amount of antenna rotation, therefore, depends on the sensitivity of the receiver, its multipath equalization capability, and its tuner interference rejection capability.

The reasons for DTV reception failure at 30 feet AGL are summarized in **Table 4**. With DTx *inactive*, there were only a couple of cases where DTV reception was possible over 360 degrees of antenna rotation, and a vast majority of the reception failures were due to weak signal (almost 75% of the test sites, for each DTV receiver). The next most common occurrence was strong multipath (about 25% of the test sites).

When DTx was *active* at 30 feet AGL, however, over 25% of the test sites had full 360-degree antenna rotation (for each DTV receiver), and the most predominant cause of failure was multipath (around 40% of the test sites). Once again, the positive effect of DTx can be seen in antenna adjustment.

Similar effects also were observed at 6 feet AGL. With DTx *inactive*, all the sites had antenna ranging failures due to weak RF signals from the distant, often terrain-blocked main Clearfield transmitter.

When DTx was *active* at 6 feet AGL, however, again over 25% of the sites had 360 degrees of DTV reception, and the number of multipath-limited failures increased as expected.

Table 4 Statistical analysis of reasons for DTV reception failure with and without DTx during antenna ranging.

Reasons for Failure	Failure Code	Reception Condition	# of Occurrences DTx *Inactive*		% of Occurrences DTx *Active*	
*	*	Antenna Height	Rx #1	Rx #2	Rx #1	Rx #2
No Failure	0	30 ft AGL	0.8	0.8	15.6	16.9
Weak Signal	1	30 ft AGL	73.7	73.4	23.8	28.6
Multipath	2	30 ft AGL	26.0	25.0	47.6	39.7
Interference	3	30 ft AGL	0.0	0.0	12.7	14.8
Signal Strength & Multipath	4	30 ft AGL	0.4	0.8	0.3	0.0
Signal Strength &Interference	5	30 ft AGL	0.0	0.0	0.0	0.0
Multipath & Interference	6	30 ft AGL	0.0	0.0	0.0	0.0
Other	7	30 ft AGL	0.0	0.0	0.0	0.0
No Failure	0	6 ft AGL	0.0	0.0	16.7	16.0
Weak Signal	1	6 ft AGL	100.0	100.0	66.7	56.0
Multipath	2	6 ft AGL	0.0	0.0	16.7	28.0
Interference	3	6 ft AGL	0.0	0.0	0.0	0.0
Signal Strength & Multipath	4	6 ft AGL	0.0	0.0	0.0	0.0
Signal Strength &Interference	5	6 ft AGL	0.0	0.0	0.0	0.0
Multipath & Interference	6	6 ft AGL	0.0	0.0	0.0	0.0
Other	7	6 ft AGL	0.0	0.0	0.0	0.0

Once again, similar field performance was observed for both DTV receivers with regard to sensitivity and multipath equalization.

DTV FIELD STRENGTH VERSUS HEIGHT

It is generally accepted that in most (although not all) cases, the RF field strength of a DTV signal will decrease with a decrease in the receiving antenna height. One possible cause for this phenomenon *not* to occur is multipath. Multipath from the ground as well as ground clutter (e.g., buildings, water towers, other large objects residing on the ground) can cause increased signal level with decreased receiving antenna height.

The analysis for signal attenuation with height was performed on the State College "peaked" signal data, that is, on the data taken at both 30 feet AGL and 6 feet AGL after the antenna was optimized for maximum received signal level. With DTx inactive (Clearfield transmitter *only*), the median *attenuation* was 9.3 dB, but with DTx active (*both* Clearfield and Pine Grove transmitters active), the median *attenuation* increased to 16.6 dB.

Conclusion

The WPSU field tests, performed in the summer and fall of 2007 in and around State College, PA, were successful at demonstrating the advantages of distributed transmission technology using the ATSC's 8-VSB transmission system. Despite very challenging terrain conditions, field strength *coverage* was increased considerably in the State College area as well as DTV *service*. The positive effects of DTx on the 5G DTV receivers far outweighed the negative self-interference effects, providing both increased DTV service and significantly expanded antenna range adjustment for both 30-foot AGL and 6-foot AGL receiving antenna heights.

However, proper DTx network design as well as deployment of good 5G or later receivers are important to successful DTV reception. Likewise, good receiving antenna characteristics can not be overlooked as well, particularly in the areas of gain and directionality. These tests also showed that the two 5G DTV test receivers from different manufacturers demonstrated similar performance during these field tests, providing encouragement for successful DTx operation in practical service extension applications.

Acknowledgments

During the time that MSW worked on this DTx field test project, a number of individuals participated in the process. Thanks to Merrill Weiss of the Merrill Weiss Group LLC for providing the skeleton of the test plan and field test vehicle design upon which MSW fleshed out the details. Likewise, WPSU's Carl Fisher was a key participant in this work, providing help in preparing the field truck and in assisting with data gathering as well as WPSU staff members Bernie Samansky, Chris Deppe, and Russ Rockwell. WPSU Operations Manager, Kate Domico, helped tremendously with getting the testing program moving forward. Thanks also goes to the Corporation of Public Broadcasting (CPB) which helped to fund this important project.

From MSW, Dennis Wallace and Gary Sgrignoli were heavily involved with the final field test vehicle design and build out as well as the final test plan, its documentation, and the data-gathering spreadsheet. Dennis was joined in the field by Bill Meintel and David Meintel to gather the data and record the results before the final analysis and report writing was performed by Gary Sgrignoli.

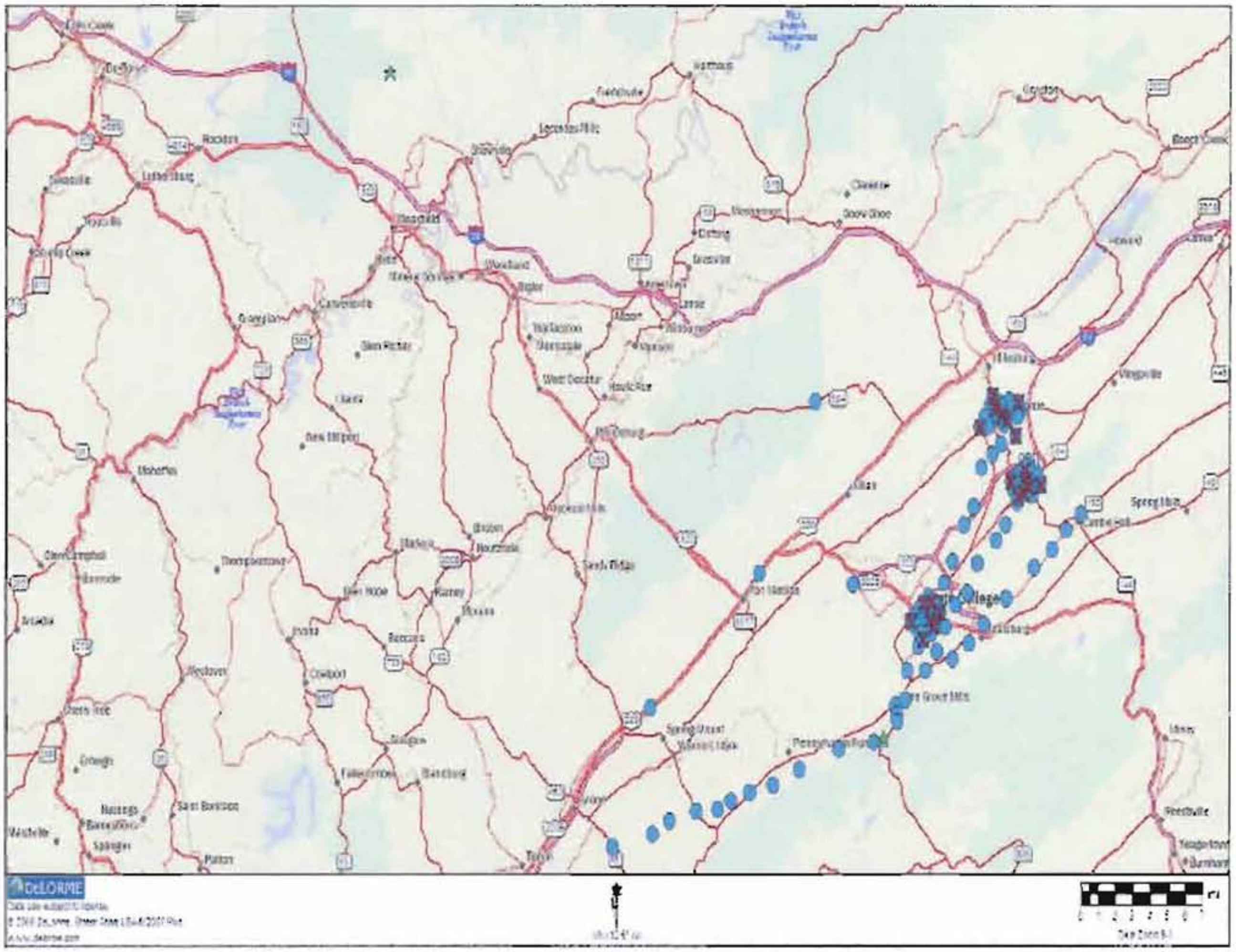

Figure 1

Map of State College Distributed Transmission field test locations – 30-foot and 6-foot receiving antenna heights

Filled circles indicate 30 only foot measurement sites – X's indicate 6/30 foot measurement sites

Stars indicate the transmitter locations

Figure 2a Photograph of WPSU field test truck with 30-foot AGL receiving antenna.

Figure 2b Photograph of WPSU 6-foot AGL receiving antenna.

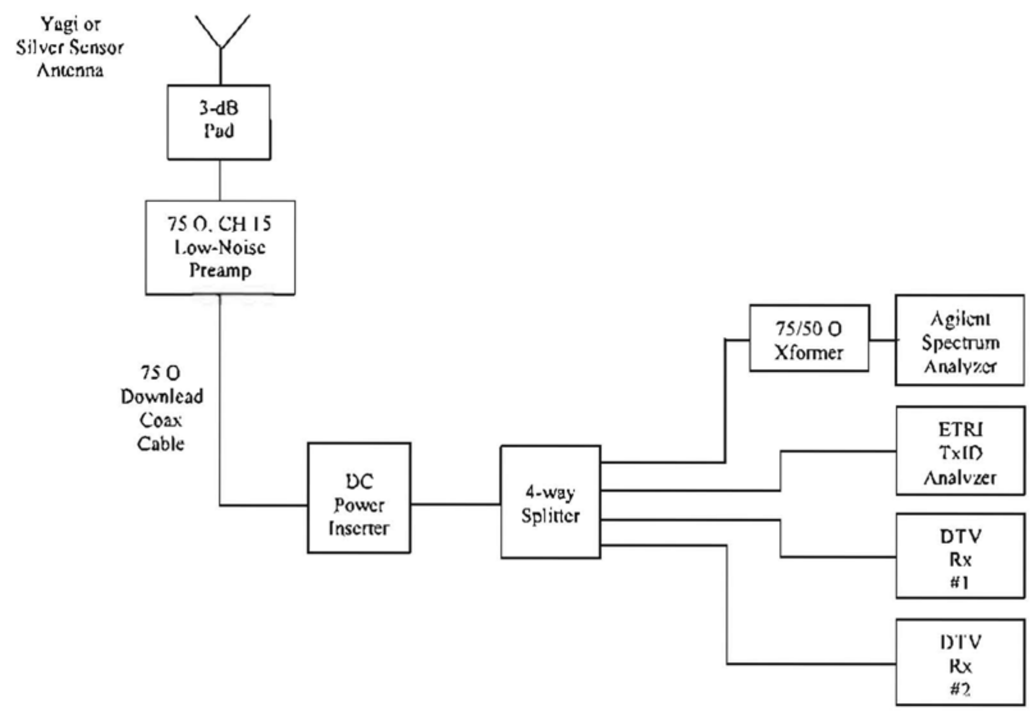

Figure 3 Block diagram of field test vehicle receiving system.

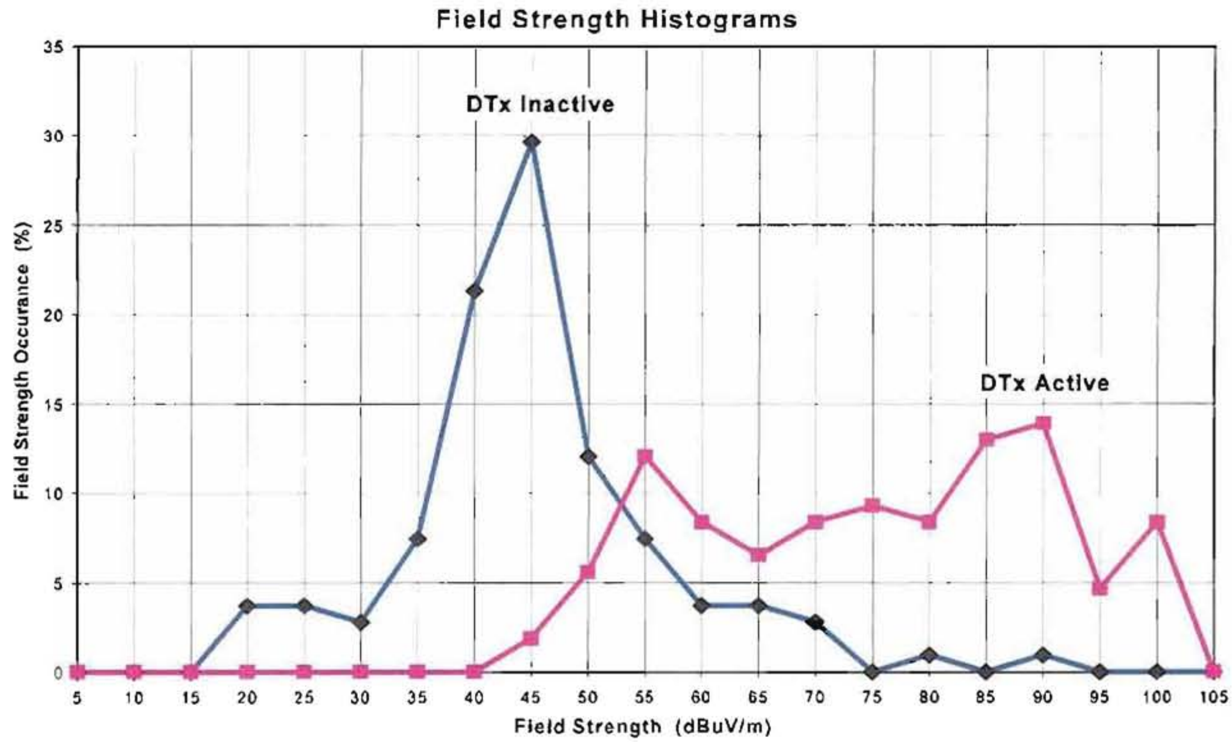

Figure 4 PDF (histogram) of field strength at 30 feet AGL with and without DTx system.

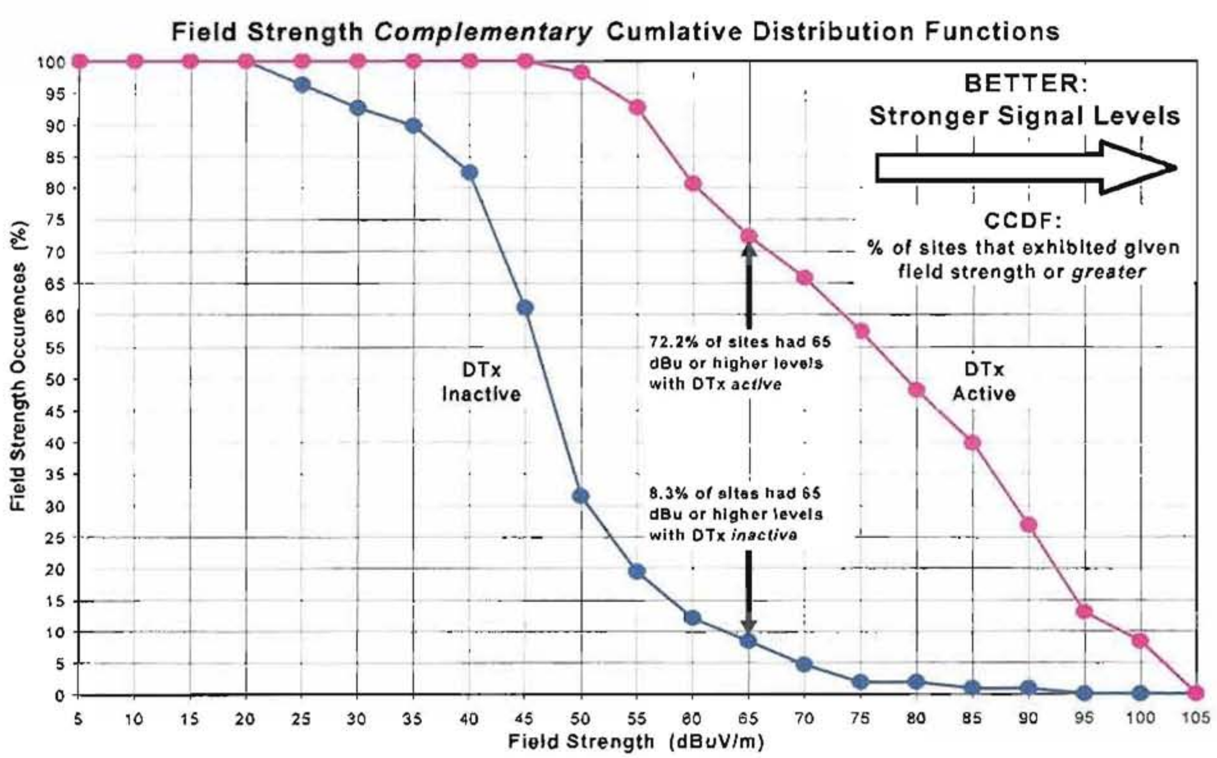

Figure 5 CCDF of field strength at 30 feet AGL with and without DTx system.

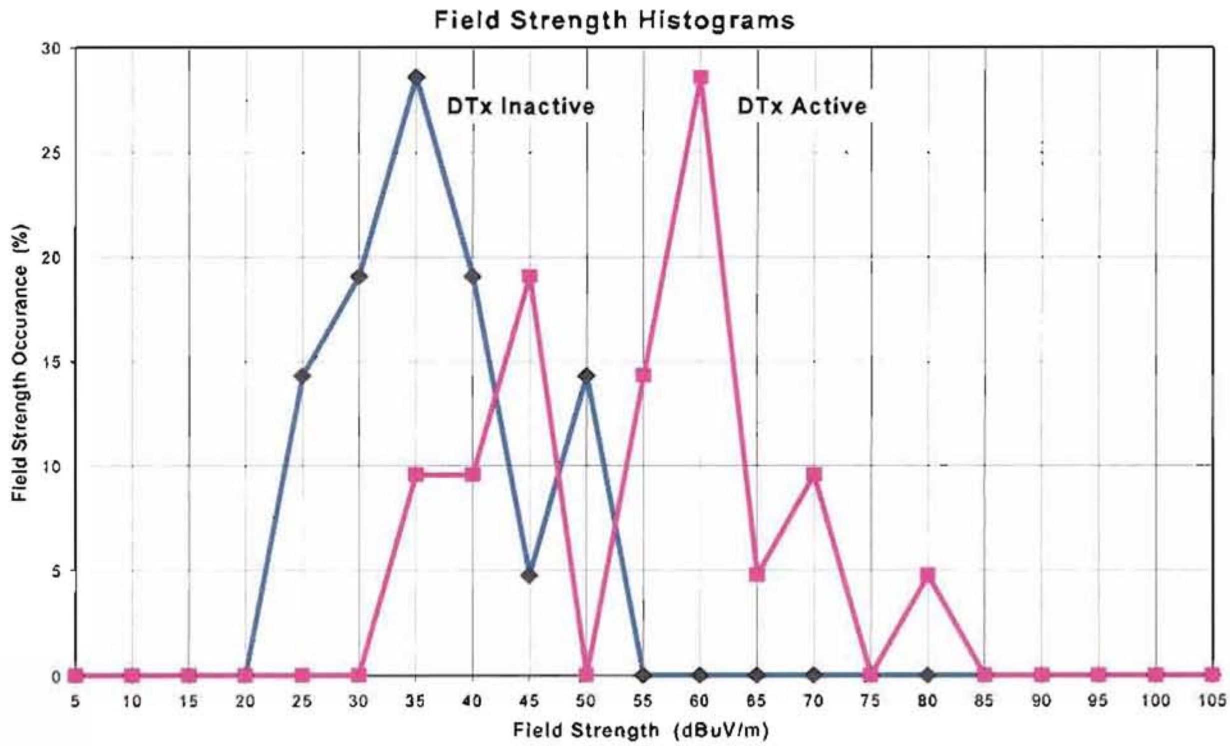

Figure 6 PDF (histogram) of field strength at 6 feet AGL with and without DTx system.

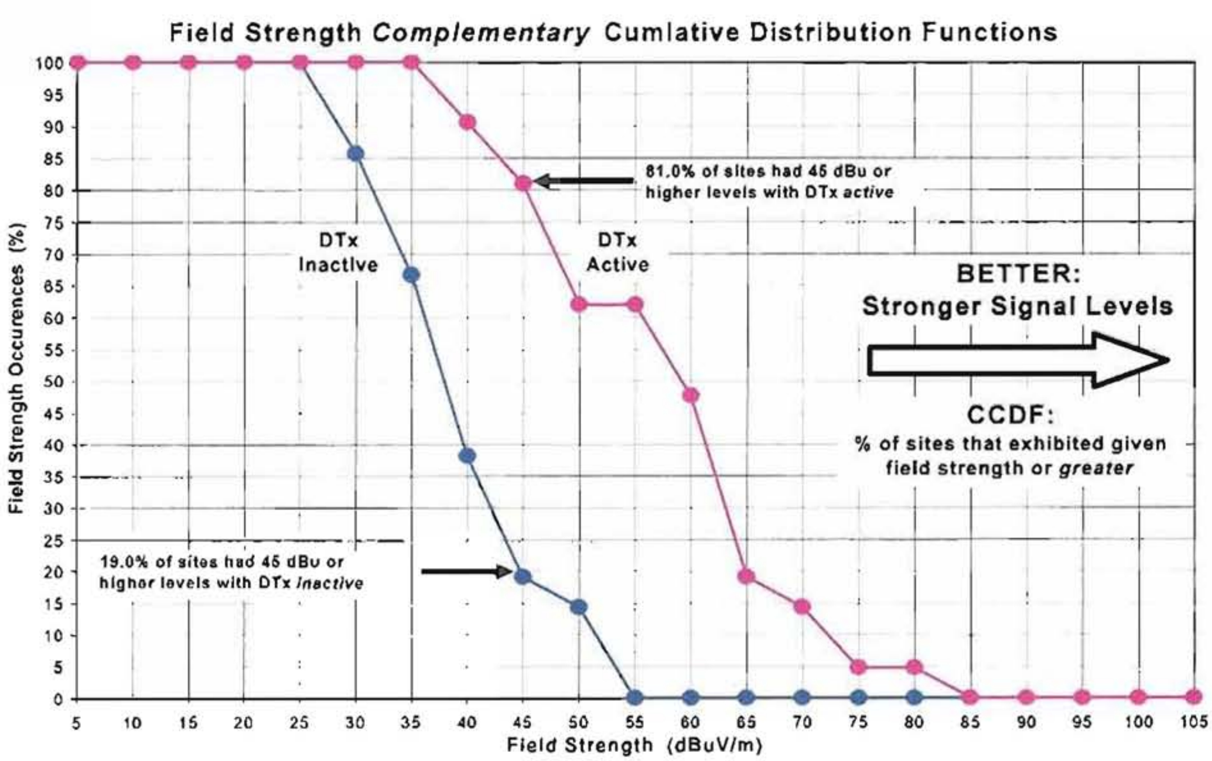

Figure 7 CCDF of field strength at 6 feet AGL with and without DTx system.

Appendix A: Data Tables

The following tables contain a *summary* of all the test site data (30 feet AGL and 6 feet AGL) organized by DTx *active* and *inactive*, antenna height reception, and DTV receiver model. Complete field test data can be found in the accompanying Excel spreadsheets (*WPSU_Field_Test_Data_30ft_120407.xls* and *WPSU_Field_Test_Data_30ft_120407.xls*).

Table A1-1 Summary of WPSU 30-foot AGL field data (108 test sites)

General Test Site Information				DTx Inactive						DTx Active						
Test Site #	Test Site Name	Clearfield Tx Distance (miles)	Pine Grove Tx Distance (miles)	Field Strength (dBμV/m)	SNR Value (dB)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)	Field Strength (dBμV/m)	SNR Value (dB)	Largest Signal (C or PG)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)
1	S02	28.1	14.8	90.7	66.6	0	0	360	360	90.9	66.8	C	0	0	304	188
2	S03	30.0	10.0	43.4	19.3	555	555	9	9	58.0	33.9	PG	0	0	43	37
3	S04	30.8	13.5	44.1	20.2	0	0	18	22	67.4	43.5	PG	0	0	214	120
4	R1-01	39.5	1.5	72.3	48.2	0	0	232	246	87.7	63.6	PG	0	0	91	100
5	R1-02	39.1	3.2	55.1	31.0	0	0	100	74	97.9	73.8	PG	0	0	360	360
6	R1-03	38.9	4.4	67.4	43.2	0	0	130	163	100.6	76.5	PG	0	0	273	260
7	R1-04	38.6	5.8	37.8	14.9	555	999	0		87.9	65.0	PG	0	0	350	354
8	R1-05	38.4	7.4	43.5	20.6	0	0	42	54	59.1	36.1	PG	0	0	241	142
9	R1-06	38.4	8.5	37.7	14.8	999	999	0	0	92.3	69.4	PG	0	0	360	360
10	R1-07	38.1	10.2	54.9	32.0	0	0	76	79	99.9	77.0	PG	0	0	360	360
11	R1-08	38.2	11.1	51.9	31.3	0	0	69	69	99.4	78.8	PG	0	0	353	355
12	R1-09	37.8	12.7	20.9	0.2	999	999	0	0	52.9	32.2	PG	0	0	83	68
13	R1-10	38.1	13.6	49.0	28.3	0	0	56	59	93.7	73.1	PG	0	0	355	351
14	R1-11	38.4	14.1	24.7	4.0	999	999	0	0	47.2	26.6	PG	555	555	0	0
15	R1-12	38.4	15.6	45.0	24.3	555	555	0	0	73.4	52.7	PG	0	0	152	90
16	R2-01	39.8	1.3	50.6	29.8	0	0	339	110	71.1	50.3	PG	555	555	0	0
17	R2-02	39.7	2.0	66.6	45.7	0	0	174	182	70.2	49.4	C	999	999	51	51
18	R2-03	39.8	3.7	44.2	23.3	555	555	0	0	78.7	57.8	PG	0	0	218	282
19	R2-04	39.8	4.8	51.9	31.0	555	555	81	46	98.5	77.7	PG	0	0	330	329
20	R2-05	39.6	5.9	54.6	33.7	0	0	72	73	92.9	72.0	PG	0	0	343	345
21	R2-06	39.5	7.0	61.1	40.3	0	0	79	80	102.3	81.4	PG	0	0	307	310
22	R2-07	39.8	7.8	45.7	24.8	999	999	0	0	100.0	79.2	PG	0	0	338	352
23	R2-08	39.6	9.2	67.4	46.5	0	0	212	208	68.6	47.7	C	999	999	0	0
24	R2-09	40.0	10.6	69.9	49.0	0	0	259	271	70.1	49.2	C	999	999	0	0
25	R2-10	40.2	11.5	45.8	24.9	0	0	40	42	54.2	33.3	C	999	999	1	0
26	R2-11	40.3	12.6	53.6	32.7	0	0	92	73	56.3	35.5	C	999	999	63	60
27	R2-12	40.5	13.4	47.4	26.6	0	0	67	65	52.0	31.2	PG	0	0	62	65
28	R3-01	40.1	1.1	79.0	57.9	0	0	208	197	79.0	57.9	C	999	555	14	0
29	R3-03	40.7	5.1	48.1	27.1	0	0	168	77	77.5	56.4	PG	0	0	202	207
30	R3-04	41.1	6.3	50.5	29.4	0	0	159	119	76.0	55.0	PG	0	0	116	163
31	R3-05	41.3	7.5	46.6	25.6	0	0	98	96	88.9	67.8	PG	0	0	248	258
32	R3-06	41.8	9.2	41.1	20.1	999	999	0	0	88.8	67.7	PG	0	0	358	350
33	R3-07	42.2	10.2	45.4	24.3	2	999	41	0	95.5	74.4	PG	0	0	360	360
34	R3-08	42.5	11.3	42.9	22.0	555	999	0	0	93.7	72.8	PG	0	0	360	360
35	R3-09	43.0	12.5	41.1	20.1	999	999	0	0	97.8	76.8	PG	0	0	360	360
36	R3-10	43.3	13.7	40.5	19.5	999	999	0	1	73.3	52.3	PG	0	0	332	349

Note: DTV CCIR ratings describe number of visible "hits" (errors) observed in 3 minutes, where 0 indicates no errors observed, 555 indicates intermittent reception, and 999 indicates no reception.

Table A1-1 (cont) Summary of WPSU 30-foot AGL field data (108 test sites)

General Test Site Information				DTx Inactive						DTx Active						
Test Site #	Test Site Name	Clearfield Tx Distance (miles)	Pine Grove Tx Distance (miles)	Field Strength (dBµV/m)	SNR Value (dB)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)	Field Strength (dBµV/m)	SNR Value (dB)	Largest Signal (C or PG)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)
37	R3-11	43.8	14.8	38.2	17.3	999	999	0	0	86.1	65.2	PG	0	0	360	360
38	R4-01	39.7	0.6	34.6	13.6	999	999	0	0	46.2	25.3	PG	555	555	0	0
39	R4-02	38.6	2.6	71.3	50.4	0	0	337	350	85.6	64.6	PG	0	0	110	129
40	R4-03	37.7	5.1	46.6	25.5	0	0	60	59	75.8	54.8	PG	0	0	201	197
41	R4-04	37.3	6.7	48.4	27.3	0	0	144	59	85.0	64.0	PG	0	0	82	81
42	R4-05	36.8	8.1	43.0	21.9	555	999	0	0	91.8	70.7	PG	0	0	360	360
43	R4-06	36.5	9.2	45.2	24.2	999	999	0	0	89.8	68.8	PG	0	0	360	360
44	R4-07	36.4	10.2	42.9	21.9	555	999	0	0	88.5	67.4	PG	0	0	360	360
45	R4-08	35.7	11.3	55.8	34.8	0	0	146	193	67.1	46.0	PG	0	0	127	110
46	R4-09	35.5	12.8	21.3	0.2	999	999	0	0	52.6	31.6	PG	0	0	180	241
47	R4-10	35.6	13.9	33.4	12.3	999	999	0	0	85.9	64.8	PG	0	0	360	360
48	R4-11	35.2	16.3	32.5	11.5	999	999	0	1	50.7	29.6	PG	555	999	136	70
49	G1-01	38.0	6.5	39.4	18.5	999	999	0	1	84.0	63.1	PG	0	0	334	324
50	G1-02	38.3	6.4	57.6	36.7	0	0	121	123	79.1	58.1	PG	0	0	214	223
51	G1-03	38.7	6.4	50.2	29.2	0	0	121	126	79.7	58.8	PG	0	0	332	360
52	G1-04	39.0	6.3	47.4	26.4	0	0	66	72	85.1	64.1	PG	0	0	329	182
53	G1-05	39.0	5.8	43.1	22.1	555	999	1	0	78.8	57.8	PG	0	0	325	333
54	G1-06	38.7	6.0	55.0	34.0	0	0	83	88	85.5	64.5	PG	0	0	310	307
55	G1-07	38.3	6.1	43.2	22.2	0	0	67	70	83.0	62.0	PG	0	0	360	360
56	G1-08	38.0	6.1	37.2	16.3	999	999	0	0	81.9	60.9	PG	0	0	360	360
57	G1-09	37.9	5.9	43.6	22.6	555	555	0	0	76.7	55.8	PG	0	0	360	360
58	G1-10	38.2	5.8	42.4	21.5	555	999	0	0	98.8	77.8	PG	0	0	360	360
59	G1-11	38.7	5.7	54.2	33.3	0	0	80	88	87.0	66.1	PG	0	0	330	333
60	G1-12	39.1	5.6	45.1	24.1	555	999	56	52	79.3	58.4	PG	0	0	276	257
61	G1-13	39.1	5.2	61.1	40.2	0	0	113	132	91.4	70.5	PG	0	0	284	286
62	G1-14	38.7	5.3	46.0	25.1	0	0	31	56	85.4	64.4	PG	0	0	342	341
63	G1-15	38.2	5.4	50.6	29.7	555	0	14	0	96.9	75.9	PG	0	0	360	360
64	G1-16	37.9	5.5	36.2	15.2	555	555	0	0	82.7	61.8	PG	0	0	360	360
65	G1-17	37.9	5.2	62.5	41.5	0	0	196	245	77.8	56.9	PG	0	0	281	293
66	G1-18	38.2	5.1	42.8	21.9	555	999	0	0	86.3	65.4	PG	0	0	360	360
67	G1-19	38.6	4.9	47.8	26.9	0	0	64	68	90.2	69.3	PG	0	0	360	360
68	G1-20	38.9	4.8	65.6	44.7	0	0	112	115	91.8	70.8	PG	0	0	239	243
69	G3-01	37.2	15.8	25.4	4.5	999	999	0	0	62.1	41.1	PG	0	0	354	340
70	G3-02	37.2	15.3	22.0	1.0	999	999	0	0	60.6	39.7	PG	0	0	360	277
71	G3-03	37.7	15.7	39.0	18.1	555	555	0	0	68.7	47.7	PG	0	0	329	315
72	G3-04	37.4	15.5	36.5	15.6	555	555	0	0	61.8	40.9	PG	0	0	360	360

Note: DTV CCIR ratings describe number of visible "hits" (errors) observed in 3 minutes, where 0 indicates no errors observed, 555 indicates intermittent reception, and 999 indicates no reception

Table A1-1 (cont) Summary of WPSU 30-foot AGL field data (108 test sites)

General Test Site Information				DTx Inactive						DTx Active						
Test Site #	Test Site Name	Clearfield Tx Distance (miles)	Pine Grove Tx Distance (miles)	Field Strength (dBμV/m)	SNR Value (dB)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)	Field Strength (dBμV/m)	SNR Value (dB)	Largest Signal (C or PG)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)
73	G3-05	38.1	16.0	29.4	8.4	999	999	0	0	58.1	37.2	PG	0	0	207	207
74	G3-06	37.5	15.3	24.4	3.5	999	999	0	0	55.0	34.1	PG	0	0	360	360
75	G3-07	37.8	15.6	34.2	13.3	999	999	0	0	71.8	50.9	PG	0	0	311	311
76	G3-08	38.7	16.2	42.0	21.1	999	999	0	0	76.3	55.3	PG	0	0	274	270
77	G3-09	38.9	15.9	40.2	19.3	0	0	43	43	51.7	30.8	PG	0	0	136	121
78	G3-10	38.8	15.7	42.8	21.8	999	999	0	0	54.8	33.9	PG	0	0	109	33
79	G3-11	38.3	15.7	39.6	18.7	555	0	0	1	63.5	42.6	PG	0	0	180	90
80	G3-12	38.0	15.3	39.0	18.1	0	0	41	46	66.8	45.9	PG	0	0	174	145
81	G3-13	37.6	15.0	26.6	5.7	999	999	0	0	49.7	28.8	PG	0	0	153	135
82	G3-14	37.1	14.8	38.5	17.6	999	999	0	0	70.3	49.4	PG	0	0	216	203
83	G3-15	37.0	14.3	22.2	1.3	999	999	0	0	52.4	31.5	PG	0	0	187	165
84	G3-16	37.5	14.5	35.4	14.5	999	999	0	0	55.1	34.2	PG	0	0	156	122
85	G3-17	37.9	15.0	33.7	12.8	999	999	0	0	74.5	53.5	PG	0	0	237	250
86	G3-18	38.3	15.3	42.2	21.3	999	999	0	0	76.0	55.1	PG	0	0	183	135
87	G3-19	38.3	15.0	29.4	8.4	999	999	0	0	66.0	45.0	PG	0	0	263	205
88	G3-20	39.0	14.9	44.0	23.1	999	999	0	0	92.0	71.1	PG	0	0	360	360
89	G2-01	40.1	14.0	46.7	25.8	0	0	58	58	83.6	62.7	PG	0	0	360	360
90	G2-02	40.1	14.2	52.9	32.0	0	0	68	70	89.4	68.5	PG	0	0	319	318
91	G2-03	40.6	13.8	39.6	18.7	0	0	44	39	64.7	43.7	PG	0	0	194	201
92	G2-04	40.8	14.2	47.2	26.2	0	0	118	62	66.6	45.7	PG	0	0	88	88
93	G2-05	41.2	14.0	50.6	29.7	0	0	156	141	54.7	33.7	PG	999	999	0	0
94	G2-06	40.5	13.2	50.2	29.2	0	0	74	74	58.2	37.3	PG	0	0	66	66
95	G2-07	40.8	13.6	40.4	19.4	555	555	43	48	53.6	32.6	PG	0	0	74	79
96	G2-08	40.7	13.7	41.4	20.4	555	555	46	0	58.6	37.6	PG	0	0	108	98
97	G2-09	39.9	12.9	40.0	19.1	999	999	0	0	77.0	56.0	PG	0	0	297	335
98	G2-10	40.6	13.5	47.3	26.4	0	0	74	74	54.3	33.3	PG	0	0	61	61
99	G2-11	40.3	13.6	40.6	19.7	555	555	18	0	69.4	48.4	PG	0	0	310	310
100	G2-12	40.1	13.6	44.9	23.9	0	0	60	62	87.0	66.0	PG	0	0	360	360
101	G2-13	39.8	13.6	43.4	22.5	0	0	60	58	90.4	69.4	PG	0	0	360	360
102	G2-14	39.7	13.4	44.2	23.2	0	0	56	56	82.0	61.1	PG	0	0	360	360
103	G2-15	40.0	13.3	37.8	16.8	0	0	17	36	72.5	51.5	PG	0	0	319	314
104	G2-16	40.4	13.2	44.1	23.2	0	0	61	60	53.3	32.3	PG	0	0	100	54
105	G2-17	40.7	13.3	45.3	24.4	0	0	64	67	51.8	30.8	PG	999	999	1	0
106	G2-18	40.9	13.4	48.0	27.1	0	0	72	76	53.2	32.3	PG	999	999	0	0
107	G2-19	39.6	13.1	39.3	18.3	555	555	0	0	59.6	38.6	PG	0	0	244	219
108	G2-20	40.2	12.8	42.0	21.0	0	0	94	49	53.7	32.8	PG	0	999	99	57

N Note: DTV CCIR ratings describe number of visible "hits" (errors) observed in 3 minutes, where 0 indicates no errors observed, 555 indicates intermittent reception, and 999 indicates no reception.

Table A1-2 Summary of WPSU 6-foot AGL field data (21 test sites)

General Test Site Information				DTx Inactive						DTx Active						
Test Site #	Test Site Name	Clearfield Tx Distance (miles)	Pine Grove Tx Distance (miles)	Field Strength (dBμV/m)	SNR Value (dB)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)	Field Strength (dBμV/m)	SNR Value (dB)	Largest Signal (C or PG)	Rx #1 CCIR	Rx #2 CCIR	Rx #1 ANT. Range (deg)	Rx #2 ANT. Range (deg)
1	G1-02	38.3	6.4	42.3	15.0	555	555	0	0	61.5	40.6	PG	0	0	93	104
2	G1-04	39.0	6.3	34.0	6.7	999	999	0	0	54.4	33.4	PG	0	555	194	74
3	G1-08	38.0	6.1	34.2	6.9	999	999	0	0	61.7	40.8	PG	0	0	351	351
4	G1-11	38.7	5.7	39.2	11.9	999	999	0	0	70.4	49.5	PG	0	0	360	360
5	G1-12	39.1	5.6	32.9	5.6	999	999	0	0	60.8	39.9	PG	0	0	355	436
6	G1-17	37.9	5.2	43.4	16.1	0	0	21	29	64.2	43.2	PG	0	0	360	360
7	G1-20	38.9	4.8	49.7	22.4	555	0	0	61	59.9	39.0	PG	0	0	102	208
8	G3-01	37.2	15.8	26.6	-0.7	999	999	0	0	58.0	37.1	PG	0	0	360	360
9	G3-06	37.5	15.3	25.6	-1.7	999	999	0	0	40.9	20.0	PG	0	0	0	0
10	G3-08	38.7	16.2	40.6	13.3	999	999	0	0	57.7	36.7	PG	0	0	342	342
11	G3-12	38.0	15.3	29.7	2.5	999	999	0	0	46.0	25.0	PG	0	0	120	0
12	G3-15	37.0	14.3	28.1	-1.1	999	999	0	0	34.8	13.9	PG	999	999	0	0
13	G3-18	38.3	15.3	36.7	9.4	999	999	0	0	56.2	35.2	PG	0	0	262	221
14	G3-20	39.0	14.9	32.5	5.2	999	999	0	0	78.6	57.6	PG	0	0	360	360
15	G2-01	40.1	14.0	33.8	6.5	999	999	0	0	69.7	48.7	PG	0	0	360	360
16	G2-05	41.2	14.0	49.0	21.7	0	0	131	128	43.6	22.6	C	999	999	0	0
17	G2-06	40.5	13.2	50.0	22.7	0	0	108	107	46.5	25.6	PG	0	0	33	61
18	G2-10	40.6	13.5	38.4	11.2	999	999	0	0	34.8	13.8	PG	999	999	0	0
19	G2-11	40.3	13.6	30.8	3.5	999	999	0	0	54.1	33.1	PG	0	0	360	360
20	G2-19	39.6	13.1	28.0	0.8	999	999	0	0	43.7	22.8	PG	555	555	0	0
21	G2-20	40.2	12.8	35.7	8.5	999	999	0	0	38.3	17.4	PG	999	999	0	0

Note: DTV CCIR ratings describe number of visible "hits" (errors) observed in 3 minutes, where 0 indicates no errors observed, 555 indicates intermittent reception, and 999 indicates no reception

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Consultants in Electronic Media Technology/Management

February 21, 2008

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, SW
Washington, DC 20554

Re: Results of Field Testing Distributed Transmission System at WPSU-DT

In granting to The Pennsylvania State University, licensee of Television Station WPSU, an Experimental License for operation of a Distributed Transmission System (DTS), the FCC sought information on the operation of the system and the answers to a few specific questions. Recently, field tests of the WPSU DTS system were conducted, and it now is possible to provide the information that the Commission sought and to answer the questions that were posed. This letter accompanies the complete report on the field testing, prepared by the firm of Meintel, Sgrignoli, and Wallace ("MSW"), and provides additional information as well as interpretation of the field test report ("MSW Report").

The overall results of the field testing are summarized in the MSW Report in its Conclusions section, in part as follows: "The WPSU field tests, performed in the summer and fall of 2007 in and around State College, PA, were successful at demonstrating the advantages of distributed transmission technology using the ATSC's 8-VSB transmission system. Despite very challenging terrain conditions, field strength *coverage* was increased considerably in the State College area as well as DTV *service*. The positive effects of DTx on the 5G DTV receivers far outweighed the negative self-interference effects, providing both increased DTV service and significantly expanded antenna range adjustment for both 30-foot AGL [above ground level] and 6-foot AGL receiving antenna heights."

To provide additional context for these results, this letter will describe certain design considerations that were taken into account in the WPSU Distributed Transmission Network (DTxN) and will compare predictions from the design model and results obtained in the field test. As is described below, such comparisons are possible because the field test, in fact, was designed specifically to enable them.

WPSU-DT Distributed Transmission Network Design

The WPSU-DT Distributed Transmission Network design, indeed the use of Distributed Transmission (DTx) technology in the first place, were driven by the challenging terrain and propagation environment in which the station is located. The WPSU-DT transmitter is located near Clearfield, PA – the city of license, and the station covers the middle of the state from the southern to the northern borders. Each of three major population centers in the station's service area is located in a separate valley near the edge of the predicted noise-limited contour (PNLC) from the Clearfield transmitter. The cities of Altoona, Johnstown, and State College are cut off from the Clearfield transmitter by the ridge of Rattlesnake Mountain.

Before Distributed Transmission technology was adopted as a solution, efforts were made to find any other means that would enable WPSU to continue delivery of its Public Television programming to the population centers once it moved from Channel 3 NTSC operation to Channel 15 digital operation. Because of the significant differences in propagation characteristics on the low VHF and UHF channels, limits placed on tower construction by FAA rules and the density of airways in the region, and a need to maintain Public Television service to the northern part of Central Pennsylvania, the only choice turned out to be construction of a maximized facility on a new, taller tower at the station's original transmitter site near Clearfield. Since the cities were blocked by terrain from the Clearfield transmitter, Distributed Transmitters placed near each major population center became the only practical solution for maintaining the station's service. The network design thus became a combination of a main, maximized transmitter and three, moderate-power "gap-filler" transmitters, all operating as Distributed Transmitters, i.e., each transmitter receiving the data to be transmitted over a Studio-to-Transmitter Link (STL) and originating its own radio frequency signals in synchronization with the other transmitters in the network.

The WPSU network design calls for a total of four transmitters, as just described, but funding initially was available only for two transmitters – the main transmitter at Clearfield and a gap-filler near State College. The other two transmitters – gap fillers near Altoona and Johnstown – recently were funded, and their design is currently under way. Application is expected to be made to the Commission for their construction in a matter of months. In the meantime, the tests described herein and in the MSW Report are based upon the performance of the network using the two initially constructed transmitters.

A major design goal for the WPSU network is to deliver signal levels strong enough in the population centers to enable reception using indoor, set top antennas. Indoor reception requires a significantly higher field strength at the standard measurement and prediction receiving antenna height of 9.1 meters (30 feet) than is required to meet the noise-limited threshold of reception determined from the normal planning factors used for such calculations. The field strength needed to meet the noise limited threshold with the standard planning factors is generally taken to be 41 dBu plus a dipole factor adjustment dependent on the frequency of operation.

For reception indoors, the field strength threshold value must be adjusted to take account of a lower antenna height (e.g., 6 feet instead of 30 feet), lower gain in the receiving antenna (e.g., 0 dB instead of 10 dB), and additional losses in penetrating the building or passing through windows (e.g., on the order of 20 dB net of a reduction in transmission line loss). In the aggregate, these values add up to approximately 40 dB of additional field strength at the 30-foot height outdoors in order to deliver the necessary power input to an indoor receiver. Thus, field strength in the range of 80 dBu is needed under standard prediction and measurement conditions to obtain reliable indoor reception. Lower values will produce indoor reception in some cases, but the location probability of indoor reception will be lower.

Another factor that entered into the design process was the ability of receivers to recover the data from multiple transmitted signals arriving at their inputs. The signals from the transmitters are synchronized intentionally to make them appear as multipath when they arrive together at receiver inputs. At the same time, in the WPSU network, since terrain is a major driver for use of Distributed Transmission technology, advantage also can be taken of the terrain to provide a certain amount of separation between the signals from the several transmitters. Through use of sufficient power in the gap filler transmitters, the fact that the signal from the main transmitter is severely attenuated in their respective service areas can allow the gap fillers to predominate in their regions, effectively reducing the level of the "echoes" created by the main transmitter and thereby making the functions of the receiver adaptive equalizers easier and improving their results.

As a consequence of these considerations, the WPSU DTxN was designed to maximize the field strength from each of the gap-filler transmitters within the valley it is intended to serve, while using the ridges between valleys to help isolate the signals from one another. There will be overlap between signals from the transmitters, however, so antenna pattern shaping also was used to aid in the reduction of the overlap of the signals and to place the increased signal levels where they would do the most good. To achieve the combination of improved signal levels where they are needed and the dominance of one transmitter over another within its individual service area, the main transmitter at Clearfield operates at a power level of about 800 kW effective radiated power (ERP – which, because of its height above average terrain [HAAT], is the equivalent of 1 MW), and the transmitter for State College, at a site known as Pine Grove Mills, operates at about 50 kW ERP. The two transmitters planned for Altoona and Johnstown are each expected to operate at about 25 kW, although that value is subject to some change resulting from the application of new antenna technology that may permit higher power levels to be achieved.

Model Predictions for WPSU-DT DTxN

In designing the WPSU DTxN, a computer model was used that takes into account as many as possible of the factors that determine expected reception performance at any given location. These factors include the predicted field strengths from each of the network transmitters, the relative arrival timing of signals from each of the transmitters, and the performance characteristics of the adaptive equalizers expected to be used in consumer receivers. Analysis of the combination of these factors permits prediction of the likelihood of good or bad reception at all locations throughout the service area of the network. Results of the analysis by the computer model are produced on and interpreted from a series of maps and charts. The results obtained for the WPSU-DT network are presented next. They will be followed by discussions of the field test design intended to confirm the operation of the network and of the performance actually obtained from the network as measured against predicted performance.

For reference, Figure 1 (which is attached to the end of this document along with all the other figures) shows the field strength predicted for the service from the WPSU main transmitter using the Longley-Rice terrain-dependent propagation model. It is clear from this map that the signals surrounding the Clearfield transmitter are strong but that they fall off precipitously at the ridge line (Rattlesnake Mountain) between the transmitter and the cities of State College, Altoona, and Johnstown.

Figure 2 shows the field strength over the service area of the network with all four transmitters included, as derived from the initial network design. The actual parameters used in constructing the Clearfield and Pine Grove Mills (serving State College) transmitters were obtained from the initial design. The exact parameters that will be used in constructing the Altoona and Johnstown transmitters may vary somewhat from those in the initial design as a consequence of fitting them into sites and facilities that will be available for use when they actually are built, which sites and facilities are likely to be different from those used in the initial design because of changes in availability with the passage of time.

The predicted field strength performance of the two transmitters built so far is shown in Figure 3. This represents the network tested in the recent field tests and reported upon in the MSW Report and this letter. Figure 4 shows the portion of the two-transmitter network service area of Figure 3 that is centered on the Pine Grove Mills transmitter site (which is denoted as WPSS on this and subsequent maps – a made-up "call sign" used to identify the WPSU transmitter covering State College). Its layout will form the basis for the remaining maps included in this discussion.

As mentioned previously, an important characteristic to take into account when designing a DTx network is the expected performance of adaptive equalizers in consumer receivers. To permit inclusion of this factor in the network design model, a typical 5th generation receiver was measured and its adaptive equalizer characterized. The performance of the adaptive equalizer is expressed in two dimensions in terms of the amplitude separation between the strongest (primary) signal received and other received signals (echoes) and in terms of the difference in arrival times at the receiver input of the several signals. The relationships between amplitude differences and time differences can be shown on plots such as those in Figure 5, which represent the same relationship looked at in two different ways.

Figure 5a shows in color the area of the plot in which the adaptive equalizer can successfully recover data from a signal arriving at multiple times, i.e., a multipath signal having a primary signal and one or more echoes. The colored area is divided into segments having different colors that represent the time displacement of the signals. The adaptive equalizer is expected to enable the receiver to correctly recover data from signals falling within the colored area. The receiver also is expected to correctly recover data from signals falling below the colored area because the echoes in that region act the same as uncorrelated noise with respect to the main signal. Thus, signals in the region below the line that traces the top of the colored area all should be correctly received.

Signals appearing in the region above the line that traces the top of the colored area in Figure 5a, on the other hand, are generally not expected to be correctly recovered by a receiver. This region is shown by the colored area of Figure 5b, in which the line that traces the bottom of the colored area is the same line that traces the top of the colored area of Figure 5a. In Figure 5b, the time offsets between the primary and echo signals are color-coded the same as in Figure 5a, but the meaning of the coloring is just the opposite, i.e., the colored area is the region where a receiver would not be expected to work rather than where it would.

With these fundamental ingredients, it is possible to map the areas where the signals from multiple transmitters in a DTx network are expected to be receivable and where they are not. At the current state of the modeling software, determining the areas where they are expected to be receivable requires combining information from several maps, while determining where they are not expected to be receivable due to interference between the transmitters can be done using a single map. It also can be instructive in designing a network to know and manage the regions in which adaptive equalizers will be needed to recover the signals, as opposed those regions where signals can be expected to be recovered without an adaptive equalizer being in operation.

For the WPSU DTx network, Figure 6 shows the areas where an adaptive equalizer can be expected to be required to enable recovery of the data from multiple signals. Figure 7 shows areas where an adaptive equalizer is predicted to be unable to enable recovery of the data. Figure 6, therefore, represents areas where an adaptive equalizer is operating in the colored regions of Figure 5a, and Figure 7 represents the areas where an adaptive equalizer is operating in the colored regions of Figure 5b, with the colors on both maps corresponding to the similarly colored time displacements in Figure 5. Receivers in areas that are not in color on either Figure 6 or Figure 7 can be expected to recover the data from the signals properly if they are in areas shown on Figure 4 to have adequate field strength.

It should be noted that there is a strip in Figure 7, extending to the northeast from the northeast corner of State College, where it is predicted that the signals will fall outside the range of the adaptive equalizer's ability to enable receivers correctly to recover the data. In that strip, the signal levels from the two transmitters are predicted to be close in field strength to one another. This is the result of the signal from the Pine Grove Mills transmitter skimming along the side of Mount Nittany, which is positioned along the southern side of the road that runs through the middle of the strip. At the southwest end of the strip, the Pine Grove Mills transmitter is not obscured, and its signal predominates. At the northeast end of the strip, the Pine Grove Mills transmitter is completely obscured, and the Clearfield transmitter can be received. In the strip itself, the Pine Grove Mills transmitter is partially obscured by the mountain, and the field strengths are about equal. With approximately equal signal levels on a receiver input, depending upon which signal is slightly stronger, the time displacement will change sign abruptly from a leading to a trailing value of the same offset. This can be seen in the jump down the middle of the strip from orange to cyan, representing time displacements in the range from – 20 to – 30 microseconds (orange) and from + 20 to + 30 microseconds (cyan). The strip described became an important area of interest to study.

Field Test Design

To confirm that the modeling approach and the WPSU network design work as expected, the field test was designed specifically to examine locations that were predicted to have reception difficulty as well as those that were predicted to have reception improvements. The field test used two primary test location arrangements: radials, of which there were four, and grids, of which there were three. The radials extended from the Pine Grove Mills transmitter site in four general directions. The grids were located in three areas that included residential communities. The locations of the test sites are shown on the map in Figure 8, where the points on the radials are represented by red dots and the points on the grids are represented by green squares. Also shown are a few special test locations represented by blue stars. Figure 9 shows the same field test points with population density overlaid so that the locations of communities are evident.

Three of the radials head in a general northeasterly direction from the Pine Grove Mills transmitter site. Starting from north and going clockwise, the first radial passes through the center of State College and ends in Bellefonte. The second radial follows the road along the north side of Mount Nittany and ends in Pleasant Gap. The third radial follows the road along the south side of Mount Nittany and ends in Center Hall. The fourth radial heads generally southwest and ends near Tyrone. The test locations along the radials are spaced about 2 km apart, and there are about twelve per radial.

The grids are placed in the communities of State College, Bellefonte, and Pleasant Gap. The State College grid is bisected by the first radial, while the Bellefonte and Pleasant Gap grids are at the ends of the first and second radials, respectively. Measurement sites in the grids are spaced about one block apart, in an arrangement of four by five points, for a total of twenty per grid.

Portions of the second radial and the Pleasant Gap grid are superimposed on the strip extending northeast from State College that is predicted to have difficult reception conditions. This is visible in Figure 10, which combines the information from Figures 7 and 8. It also should be noted that there is another area predicted to have difficult reception conditions along the ridge on which the Pine Grove Mills transmitter is located and through which the radials pass. The area is shown in yellow in Figures 8, 9, and 10. It is an area where the terrain rises high enough that the signal from the Clearfield main transmitter passes over Rattlesnake Mountain and arrives with a strong field strength. At the same time, the signal from the Pine Grove Mills transmitter is attenuated in that area by the antenna elevation pattern.

Measurements were taken at all radial and grid test locations with the receiving antenna at an elevation of 9.1 meters (30 feet) above ground. In addition, measurements were taken at a total of 21 of the same locations (seven in each grid) with a receiving antenna elevation of 1.8 meters (6 feet) above ground. The 9.1 meter measurements match the standard antenna elevation for the propagation prediction method specified in the FCC rules and in OET Bulletin No. 69. The 1.8 meter measurements were meant to be roughly equivalent in height to antennas used indoors in some of the more difficult receiving locations.

Performance of WPSU-DT DTxN vs. Predictions

The results of the field test, as enumerated in the MSW Report, are shown geographically in the map of Figure 11 for the 9.1 meter (30 foot) measurements, shown overlaid on a map of the predicted areas where the received signals are expected to be outside the adaptive equalizer operating range. In that map, blue dots represent locations at which reception was not significantly improved by the use of DTx techniques but was not harmed either. Green, upward-pointing triangles represent locations at which reception was improved by the use of DTx methods, and red, downward-pointing triangles represent locations at which reception was deteriorated by the use of DTx methods.

As is evident in Figure 11, there are a number of locations (blue dots) where there was no change in reception from the use of DTx techniques, and there are many locations (green triangles) where reception was improved. There also are a few locations (9 red triangles) where reception deteriorated from the use of DTx methods. Significantly, every one of the places where reception deteriorated was in or immediately adjacent to an area where ease of reception was predicted to be reduced. Thus, in the case of the WPSU DTx network, the model used proved to be perfectly accurate in predicting where ease of reception should be expected to be reduced. It also was the case that the WPSU DTx network performed according to its design, improving reception in large areas and causing reductions in reception performance only in the small areas where such reductions were predicted.

Figure 12 shows the results from the measurements made at 1.8 meters (6 feet), presented geographically, overlaid on a map of the predicted areas where the received signals are expected to be outside the adaptive equalizer operating range. The measurement points are a subset of the points shown in Figure 11. The results are presented again using blue dots for points with no significant improvement, green, upward-pointing triangles for points where reception was improved by the use of DTx methods, and red, downward-pointing triangles for points where reception deteriorated when DTx methods were used. As in Figure 11, there are a few points (blue dots) where there was no change in reception from the use of DTx techniques, there are many locations (green triangles) where reception was improved, and there is one location (red triangle) where reception deteriorated with use of DTx methods. As in the 9.1-meter case, the point at which deterioration was found was located at a site where performance outside the adaptive equalizer operating range was predicted (although it should be noted that the prediction was made for a 9.1-meter receiving antenna height).

Conclusions

Reiterating a portion of the MSW Report conclusions, "The WPSU field tests, performed in the summer and fall of 2007 in and around State College, PA, were successful at demonstrating the advantages of distributed transmission technology using the ATSC's 8-VSB transmission system. Despite very challenging terrain conditions, field strength *coverage* was increased considerably in the State College area as well as DTV *service*. The positive effects of DTx on the 5G DTV receivers far outweighed the negative self-interference effects, providing both increased DTV service and significantly expanded antenna range adjustment for both 30-foot AGL [above ground level] and 6-foot AGL receiving antenna heights."

The field test of the WPSU DTx network demonstrated that Distributed Transmission works and is a useful technique for improving reception of ATSC Digital Television signals over large areas. It can provide sufficiently high field strengths that indoor reception should be reliably obtainable in places that otherwise would have unreliable or no reception. The field test also showed that the WPSU DTx network design is nearly optimal, in that reception degradation from interference between the network transmitters is limited to a small total area. These results also indicate that the transmitter power levels selected for the network are appropriate for achieving the intended goals.

Respectfully submitted,

S. Merrill Weiss

S. Merrill Weiss, President
Merrill Weiss Group LLC

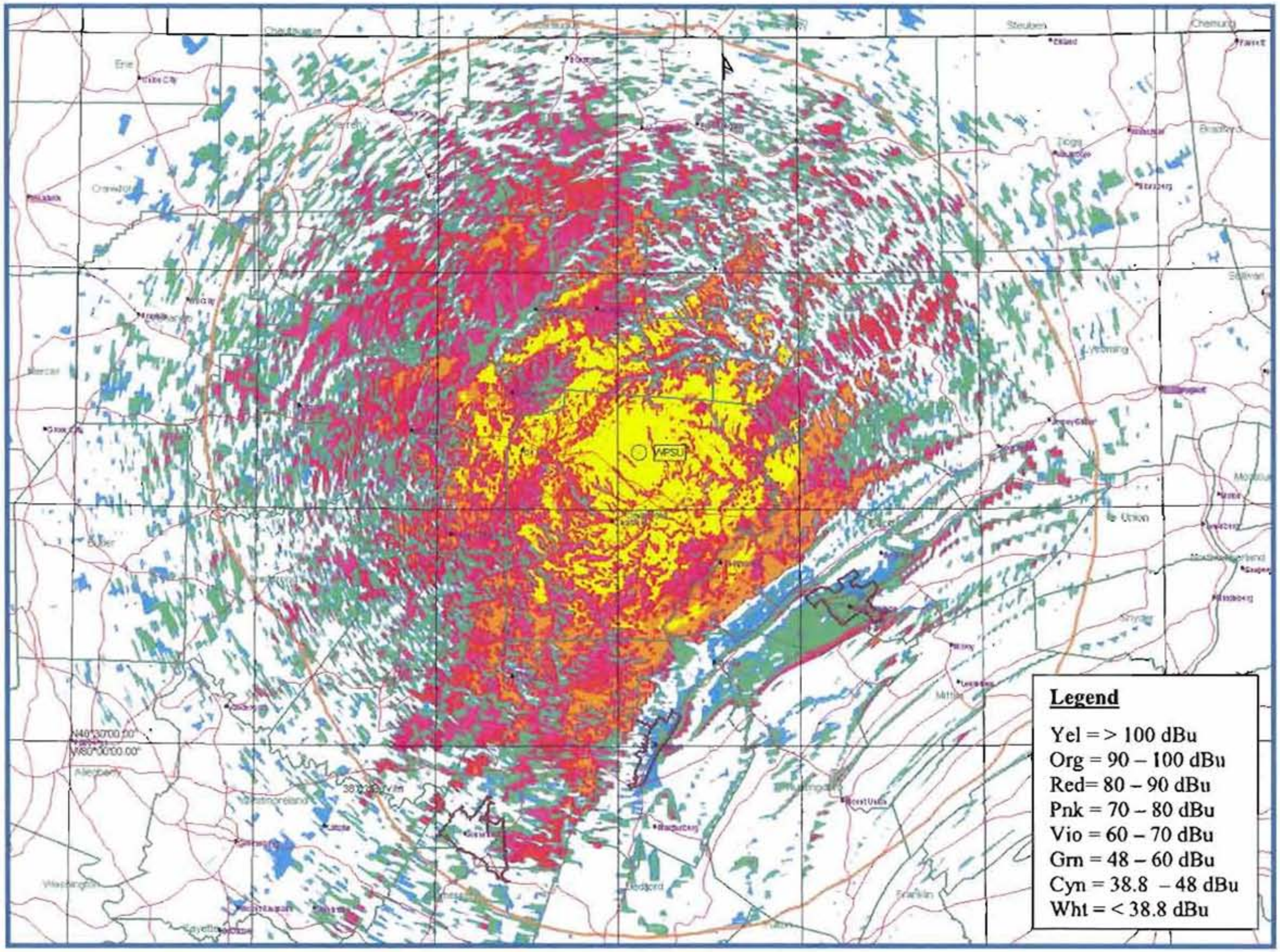

Figure 1 — WPSU-DT Main Transmitter with Maximized Facilities

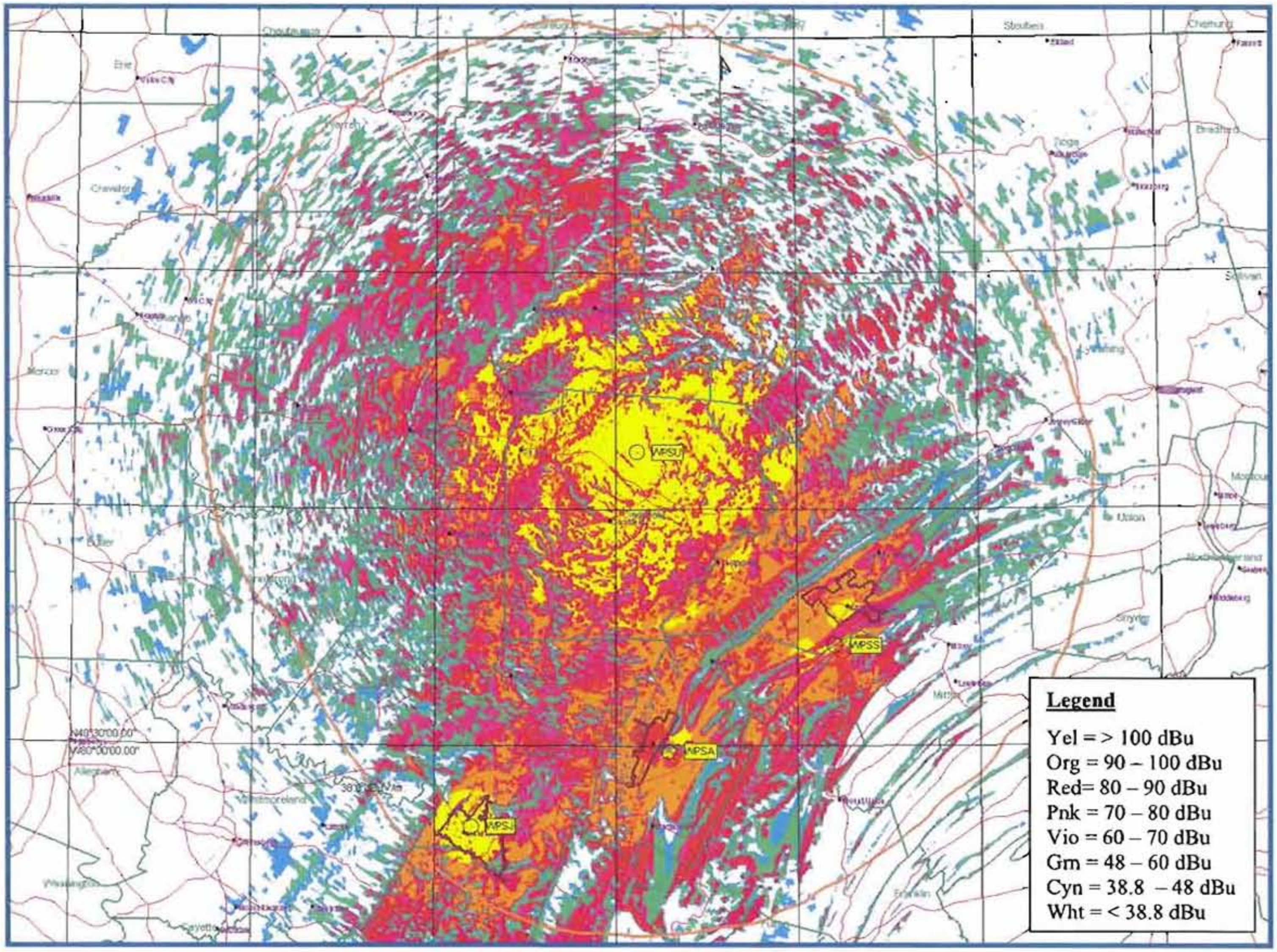

Figure 2 — WPSU-DT Distributed Transmission Network Design

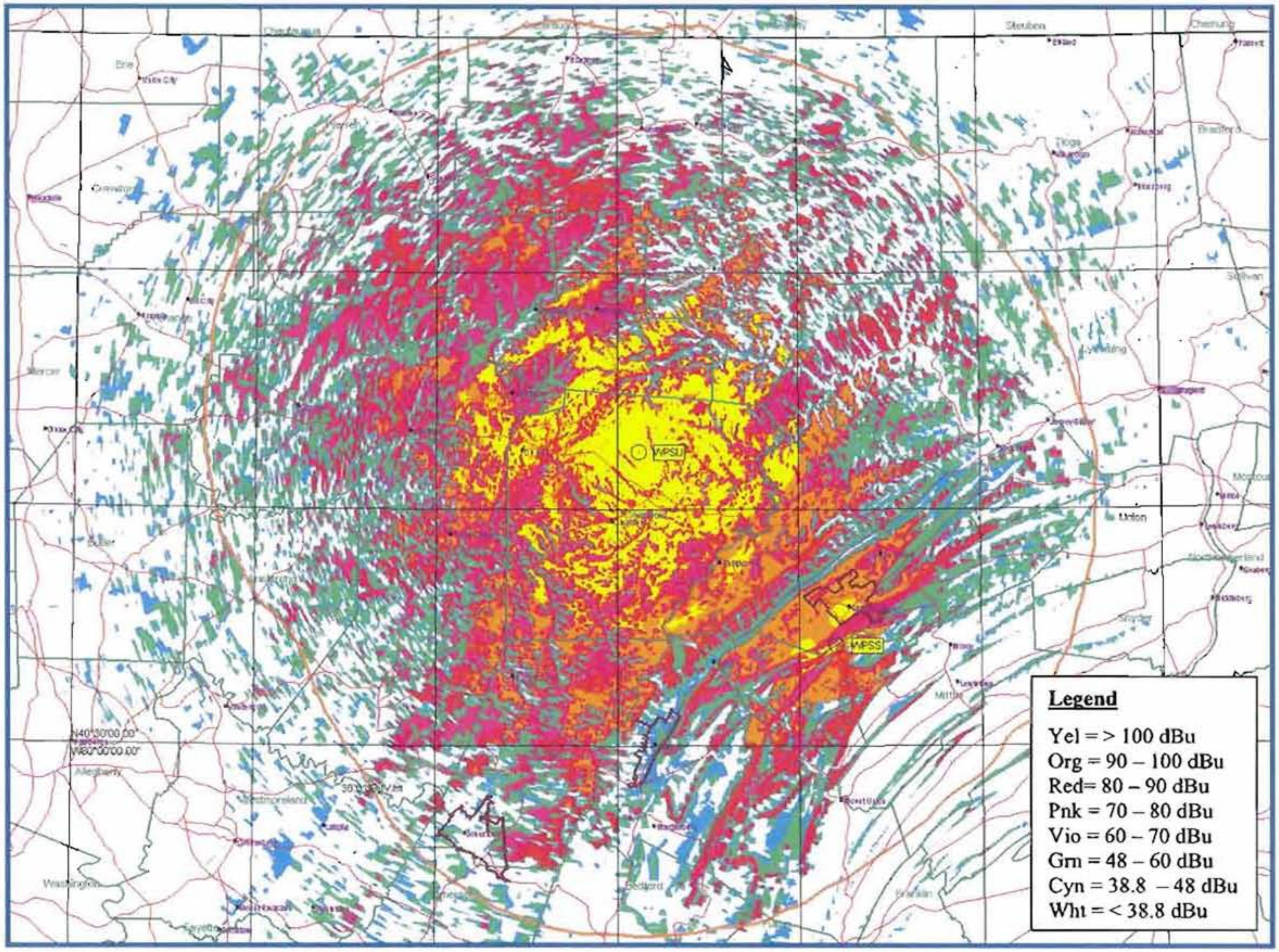

Figure 3 — WPSU-DT Distributed Transmission Network – Operating

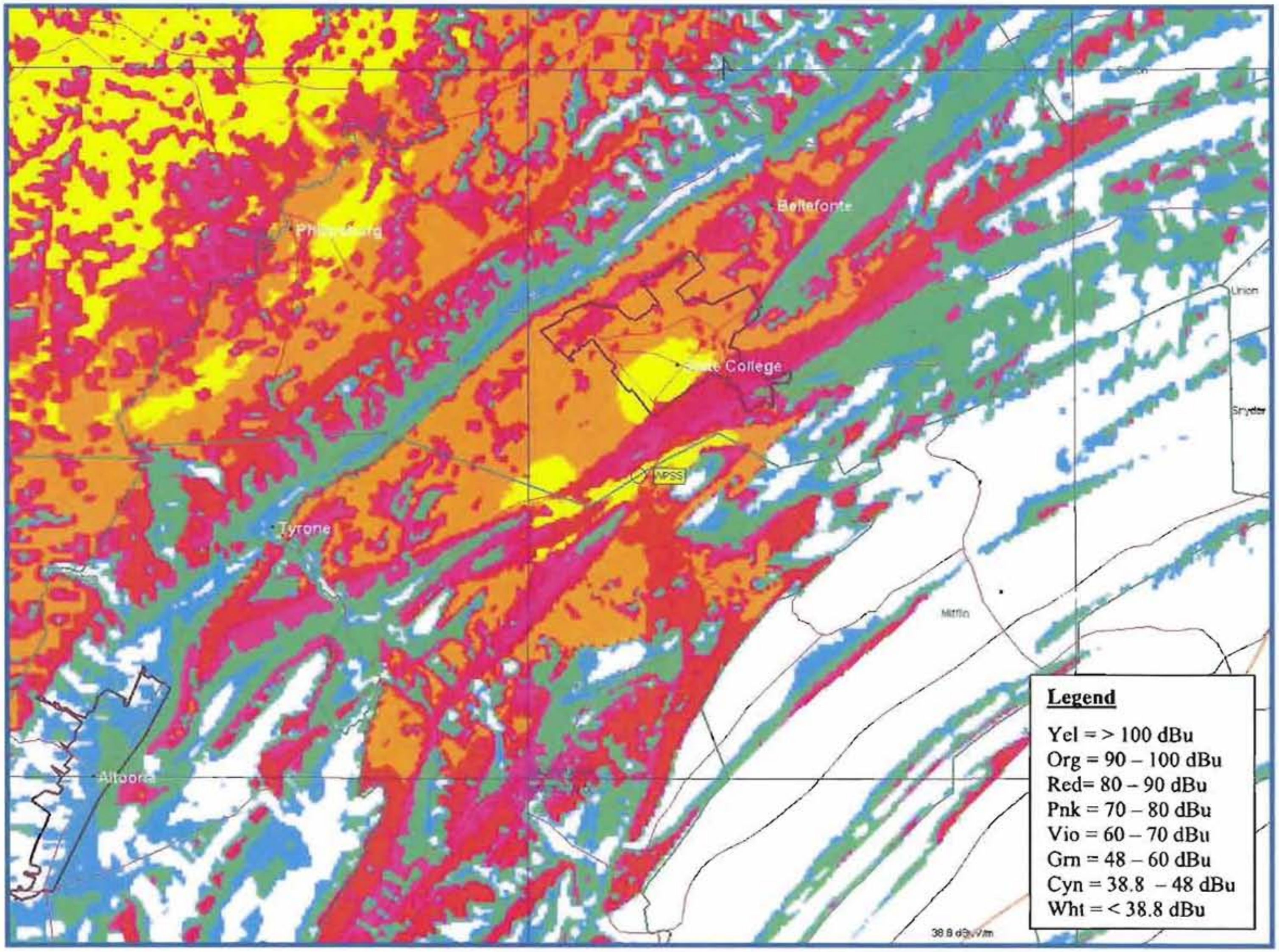

Figure 4 — WPSU-DT DTx Network – Current Implementation in State College Region

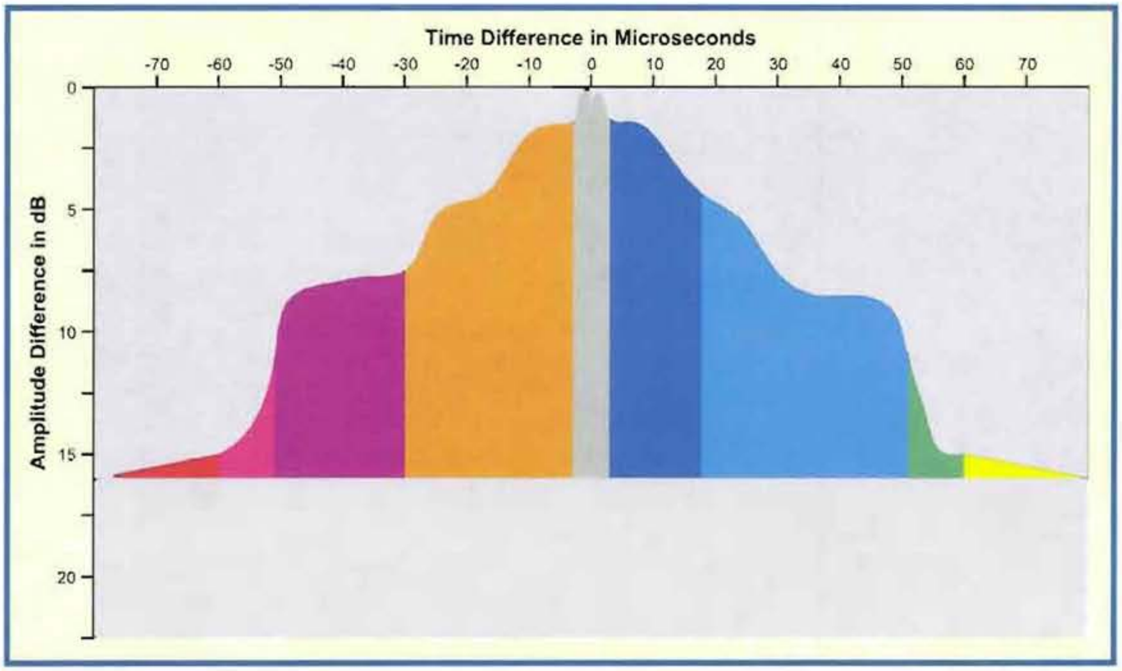

Figure 5a — Adaptive Equalizer Mask – Typical 5th Generation Receiver

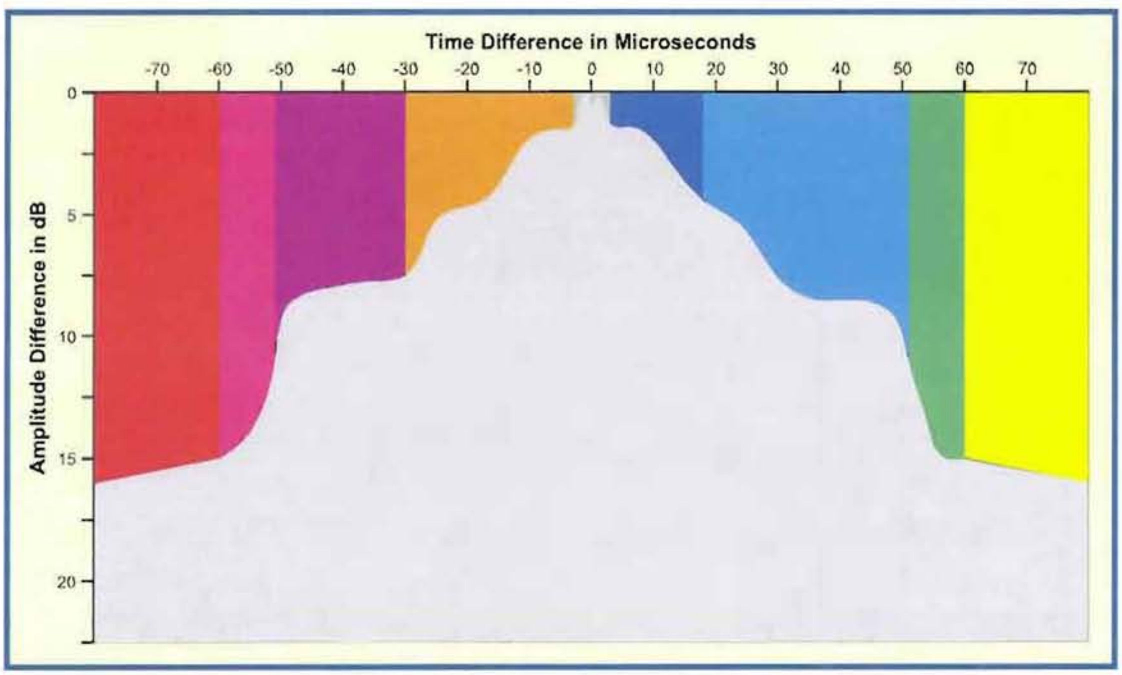

Figure 5b — Exceeding Adaptive Equalizer Mask – Typical 5th Gen Rcvr

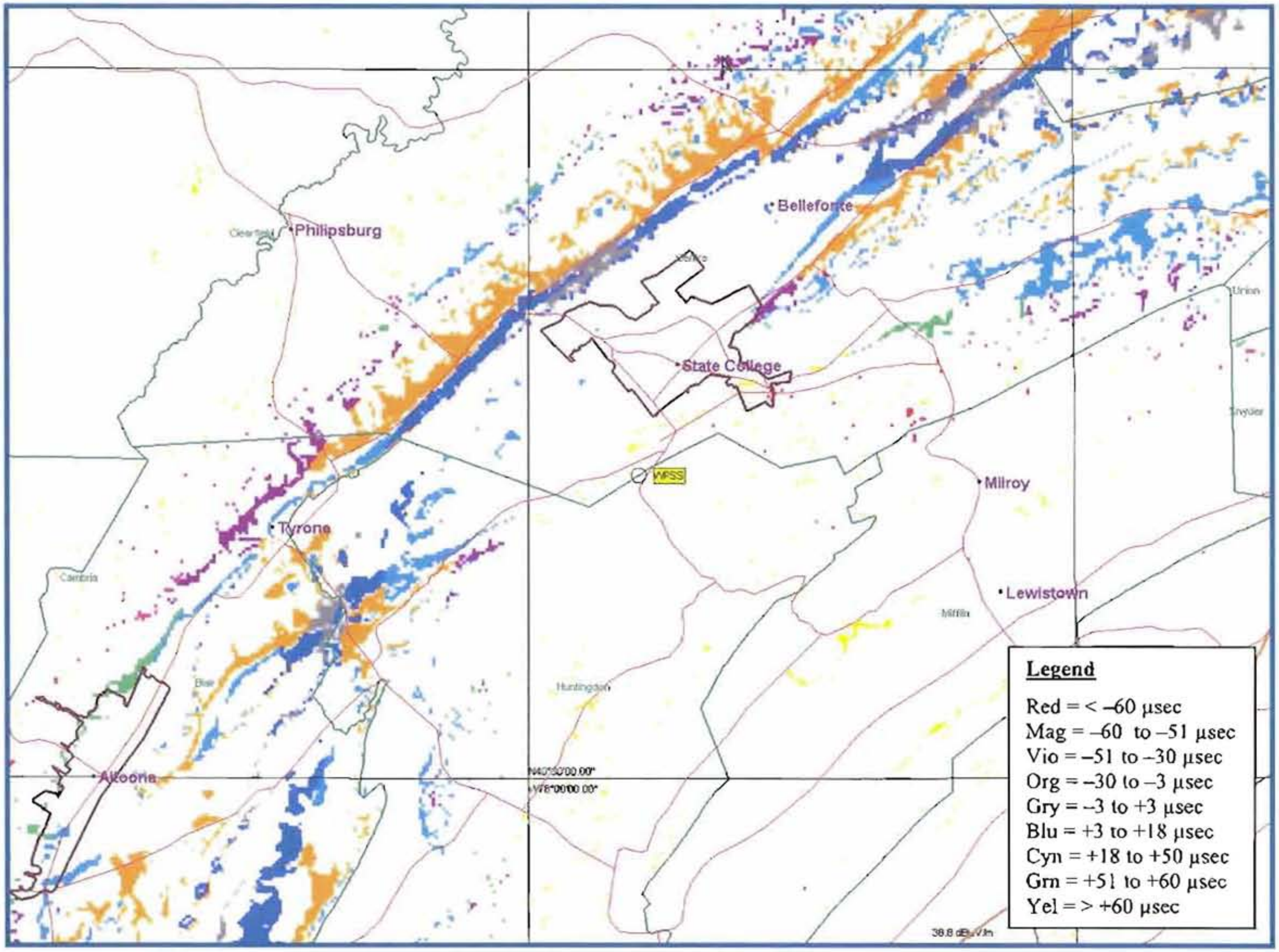

Figure 6 — WPSU-DT DTxN Performance Within Adaptive Equalizer Mask

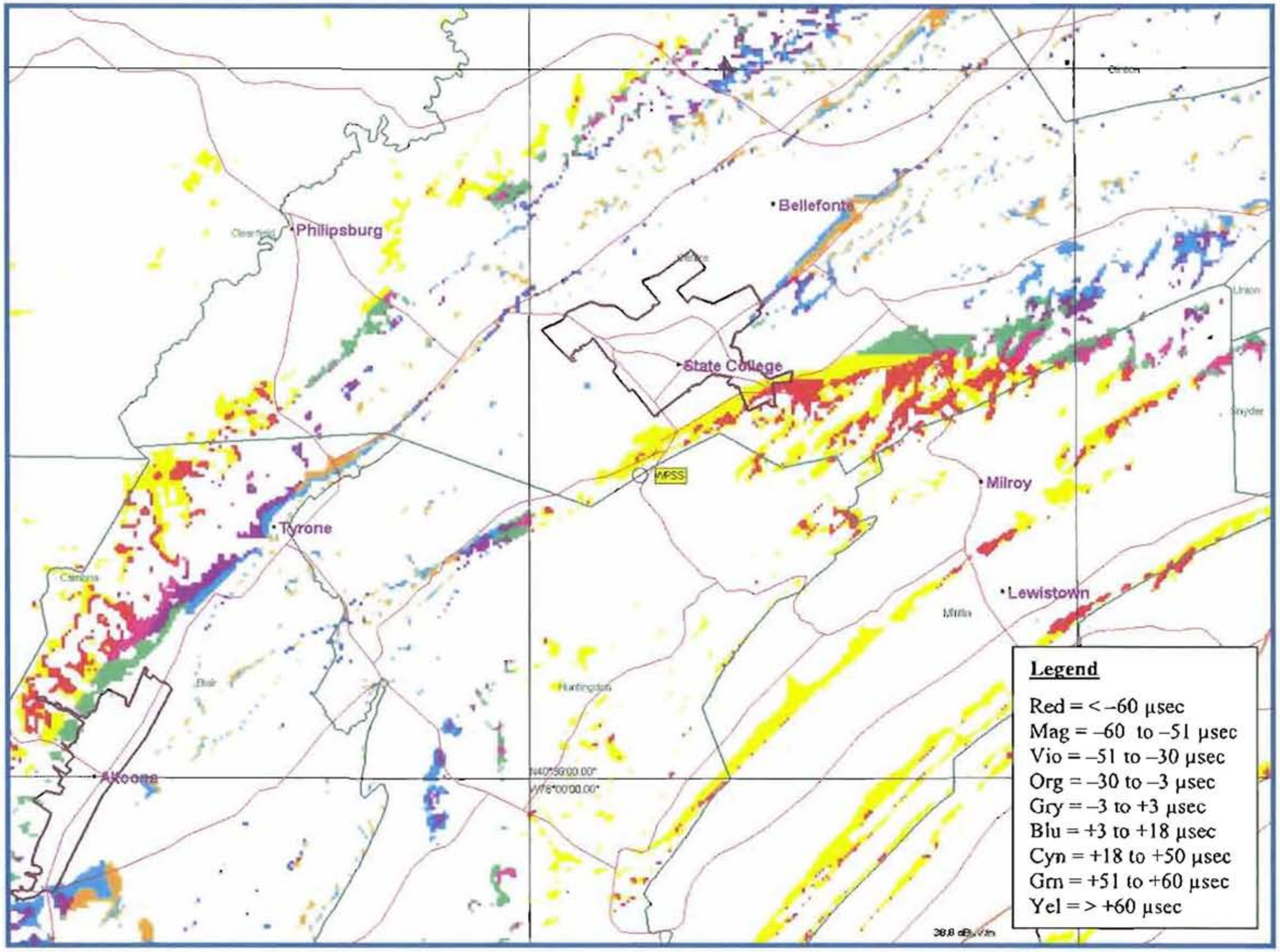

Figure 7 — WPSU-DT DTxN Performance Outside Adaptive Equalizer Mask

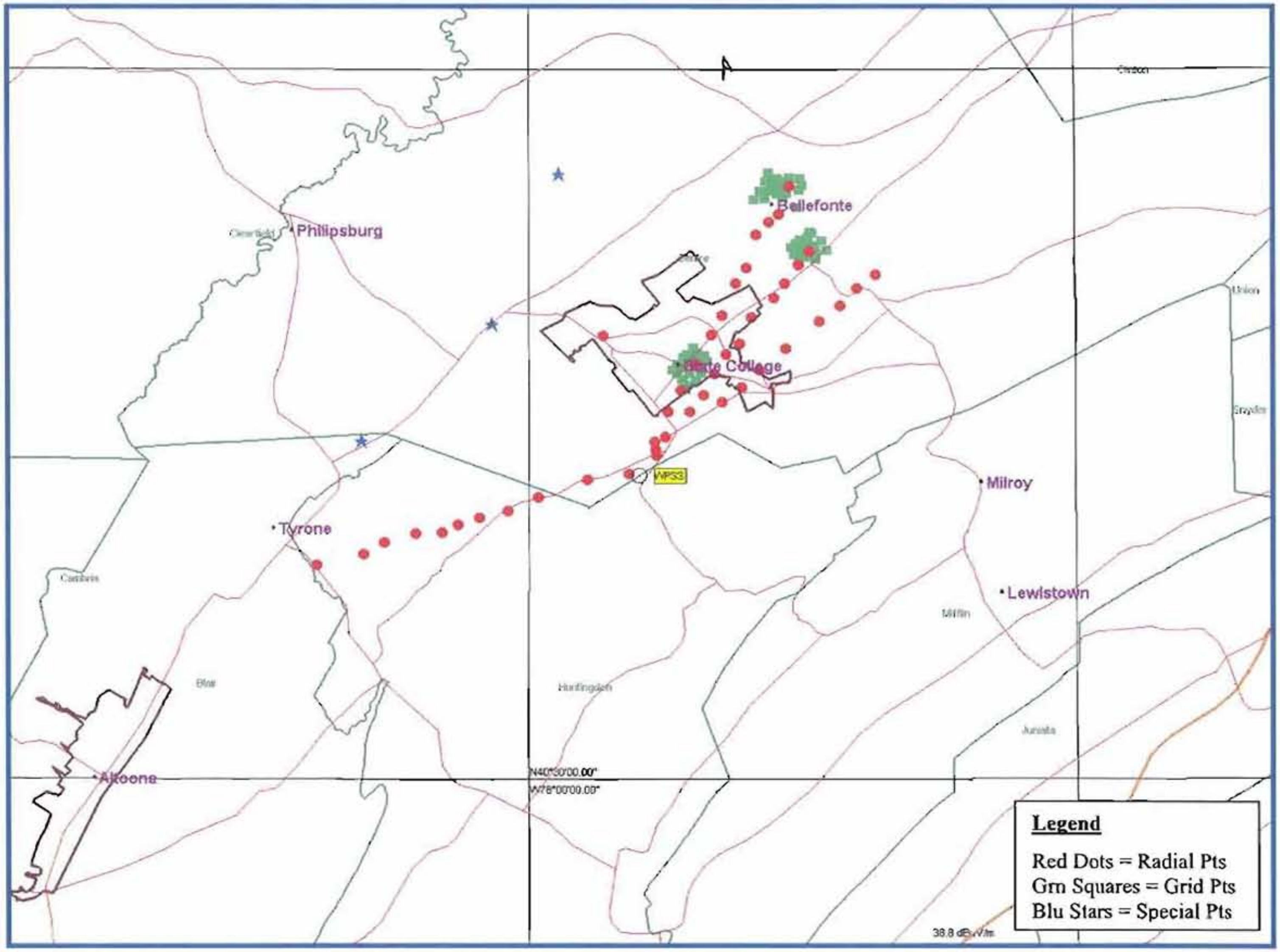

Figure 8 — WPSU-DT Field Test – Radials (4), Grids (3), & Special Sites (3)

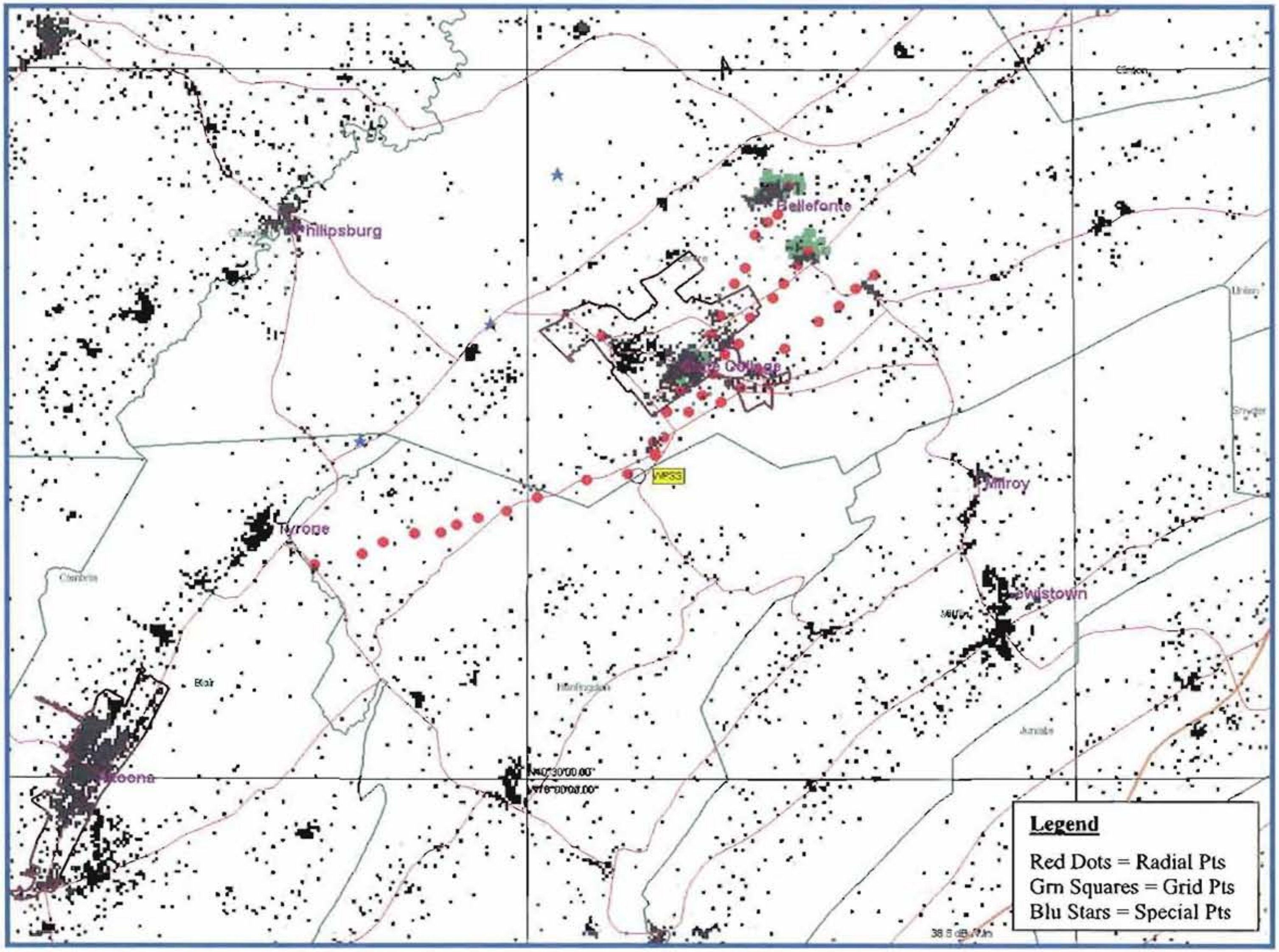

Figure 9 — WPSU-DT Field Test – Radials (4), Grids (3), & Special Sites (3) with Population Overlay

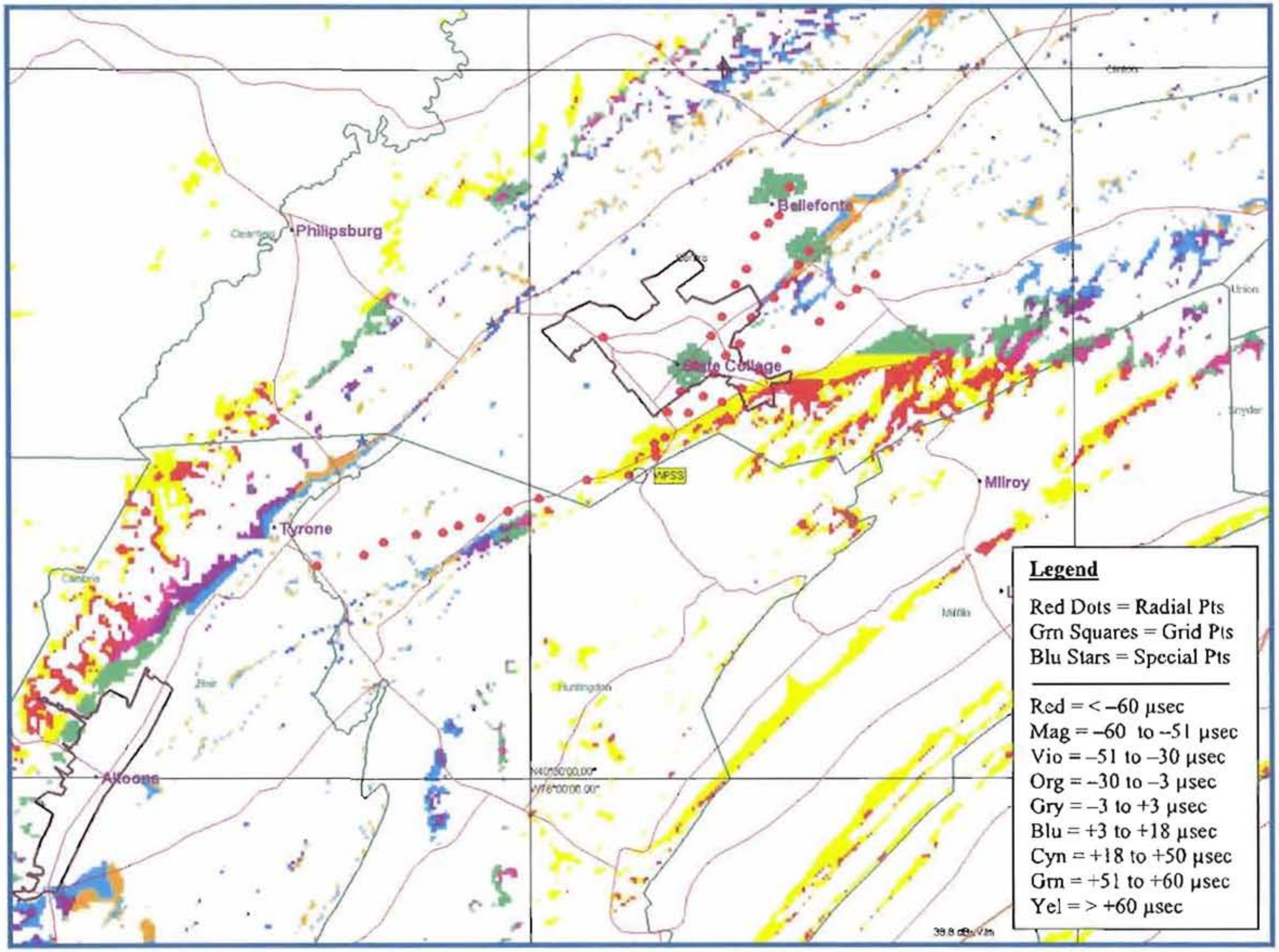

Figure 10 — WPSU-DT Field Test – Radials, Grids, & Special Sites with Performance Outside Equalizer Mask

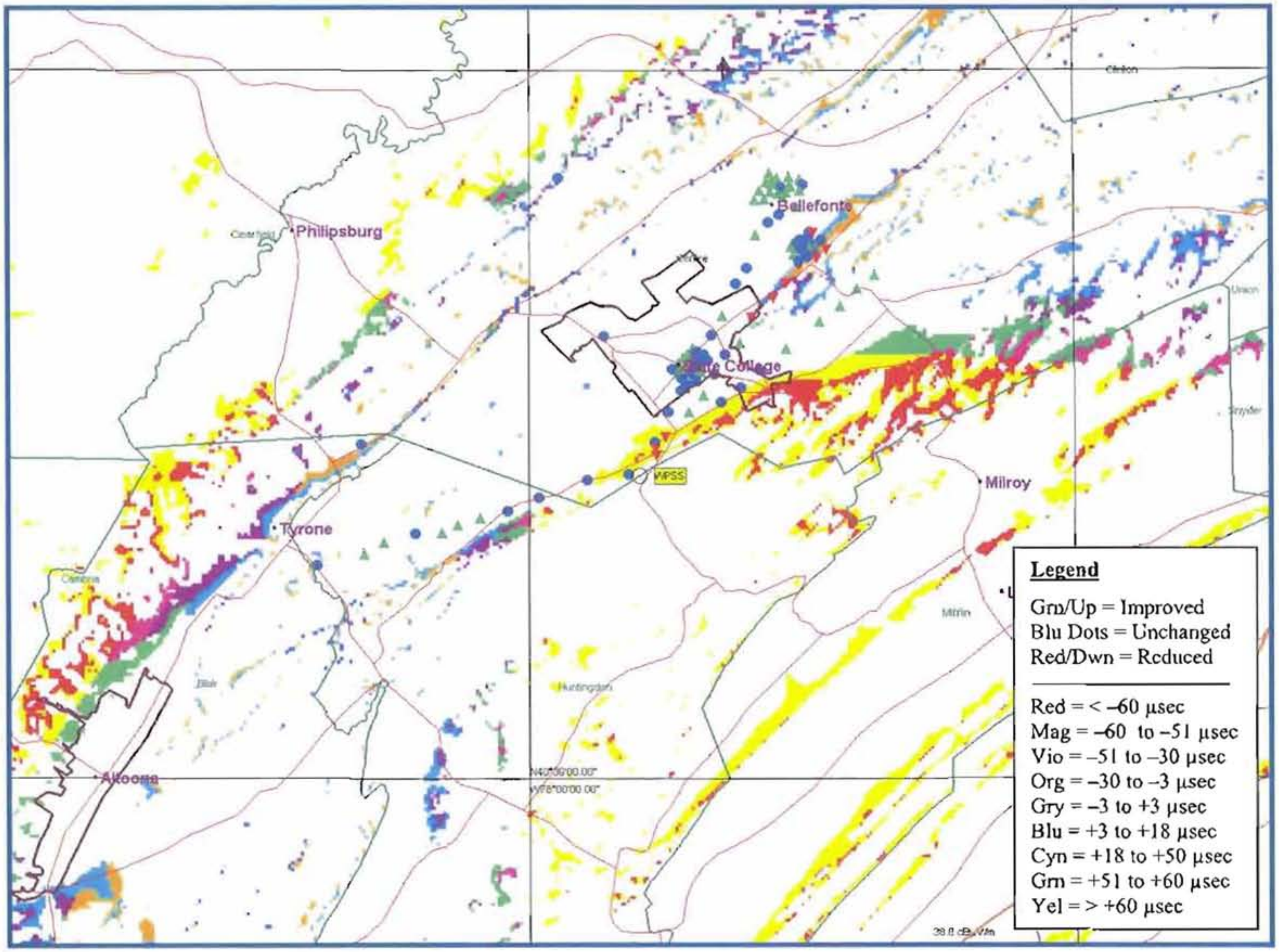

Figure 11 — Results at WPSU-DT Field Test Points at 9.1 meters versus Performance Outside Equalizer Mask

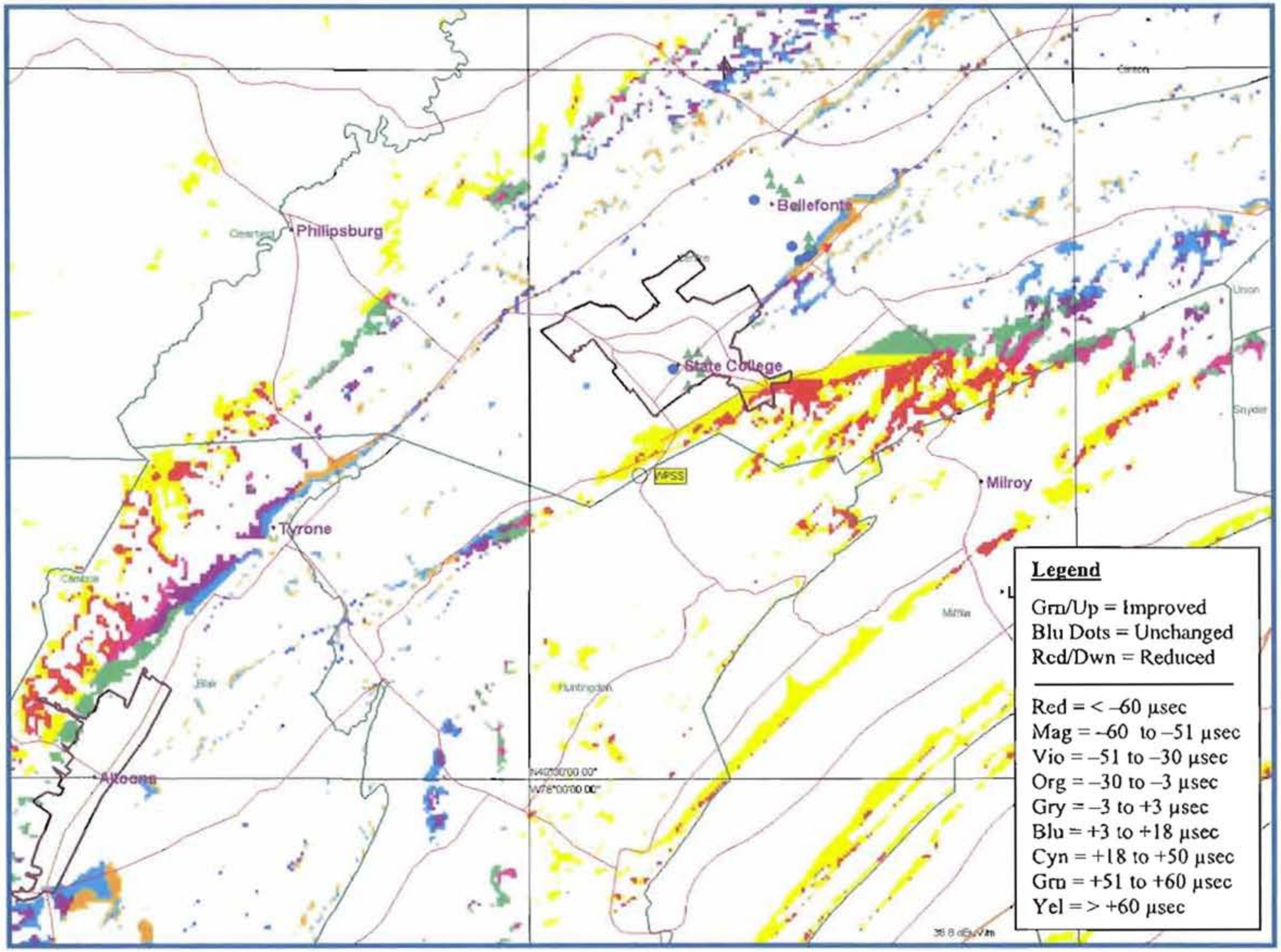

Figure 12 — Results at WPSU-DT Field Test Points at 1.8 meters versus Performance Outside Equalizer Mask

Note: Predicted performance outside adaptive equalizer mask was calculated for 9.1 meter receiving antenna height.

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Consultants in Electronic Media Technology/Management

Supplementary Report with Application for Renewal of Experimental Broadcast Station License by The Pennsylvania State University — WPSU-DT

File Number BPEXT-20010608ABD

This report provides the supplemental information required by Section 74.113(a) of the FCC rules to support the renewal application of the Pennsylvania State University for its Experimental Broadcast Station License in File Number BPEXT-20010608ABD. The language of the rules section is copied below in italics, and the corresponding information items are supplied following each of the requirements specified in the rule.

(a) A report shall be filed with each application for renewal of experimental broadcast station license which shall include a statement of each of the following:

(1) Number of hours operated.

The experimental transmitter that serves the State College, PA region from its Pine Grove Mills, PA site is part of a Distributed Transmission (DTx) network that includes the main WPSU-DT transmitter located at Clearfield, PA. With the exception of some early periods when a number of issues with network operation were resolved, the DTx network has been in operation, virtually continuously, since July 3, 2003. The period of operation thus covers approximately 247 weeks to the end of March, 2008, which equates to about 41,500 hours.

(2) Full data on research and experimentation conducted including the types of transmitting and studio equipment used and their mode of operation.

The station has been operating with studio equipment completely normal for digital television (DTV) program distribution. There is added to the usual complement of gear a Distributed Transmission Adapter (DTxA), at the input of the Studio-to-Transmitter Link (STL), which provides the necessary signaling to permit the transmitters in the DTx network to operate synchronously with one another.

The distributed transmitters (DTxTs), on the other hand, are of a design that includes in their exciters the circuitry necessary to permit them to synchronize to the output data stream of the DTxA. Through such synchronization, the signals from the transmitters appear to receivers as echoes of one another, thereby allowing the receivers to extract the data from the multiple (i.e., multipath) signals that they receive.

Operation of the DTx network recently has been characterized through a field test program, and the results of that effort are included with this report in the form of reports from the firm of Meintel, Sgrignoli, and Wallace (MSW) on the field testing itself and from the Merrill Weiss Group LLC (MWG) on the implications of the field test results.

(3) Data on expense of research and operation during the period covered.

Over $100,000 has been spent during the period since July, 2003, on engineering and field testing the DTx network.

(4) Power employed, field intensity measurements and visual and aural observations and the types of instruments and receivers utilized to determine the station service area and the efficiency of the respective types of transmissions.

The experimental transmitter at Pine Grove Mills covered by the license for which renewal is sought has been operated at approximately its authorized value of 50 kW ERP (typically 48 kW) for the entire period during which it has been on the air. The associated main transmitter at Clearfield, which is designed to operate at 810 kW ERP, has been operating at about 537 kW ERP under STA due to coordination issues with Canada.

The results of field intensity measurements and observations of the ease of reception of the DTV signals, as indicated by range-of-rotation evaluation, are reported in the field test report from MSW that accompanies the current application for renewal of the license. Also described in the MSW report are the types of instruments and receivers used to determine the station service area and the efficiency of operation of the DTx network.

(5) Estimated degree of public participation in reception and the results of observations as to the effectiveness of types of transmission.

Anyone who has watched WPSU-DT in the valley that contains State College, PA – known as Happy Valley – has watched the signals from the experimental transmitter. Anecdotally, there are viewers of the station in that area, as indicated by telephone calls received with reports of digital signal reception. The extent of viewing is not known, but WPSU is the only public television station in the central part of Pennsylvania. Therefore, in a college community such as State College, a substantial viewership of the station is to be expected.

The effectiveness of the type of transmission used – a single-frequency network (SFN), based on distributed transmission – is described in the reports of MSW and MWG that accompany this report. In summary, they found the techniques used by the station to be quite effective in expanding the areas in which service is provided and improving the ease of reception in those areas where the signals are received.

(6) Conclusions, tentative and final.

Conclusions reached are that the distributed transmission method works effectively to extend DTV service to areas that otherwise would not receive it due to terrain obstructions; that it is possible to mitigate the interference between transmitters in a distributed transmission network by synchronizing them with one another and by adjusting the relative arrival times of the signals from several transmitters at receivers within the target service area; and that the synchronization methods arrived at and now standardized are capable of enabling synchronized operation of the transmitters in a practical implementation using microwave STLs.

(7) Program of further developments in broadcasting.

The next stages planned for the development of the WPSU-DT DTx network are the installations of distributed transmitters to serve the valleys in which are located the cities of Altoona and Johnstown. They are the other two major population centers within the WPSU-DT service area that are cut off from the station's main transmitter by obstructive terrain. The added transmitters will be fed by extensions of the microwave STL system that feeds the Pine Grove Mills transmitter and will be used to prove that the techniques developed to enable a pair of distributed transmitters can be applied to a more extensive network.

(8) All developments and major changes in equipment.

When the DTx network first was installed, the distributed transmitters were locked with respect to their output frequencies to an external reference (in fact, to the reference frequency derived from GPS satellites). They were locked to the output data stream from the DTxA with respect to the derivation of the symbols they were to transmit so that their outputs matched one another, and their emission timing also was derived completely with reference to the DTxA output. It was found, however, that this arrangement did not compensate for variations in delay through the STL delivery path that occur in practical microwave systems.

Because of the great stability that is needed in the data rates, very long loop times were needed in to reconstruct the data streams at the outputs of the STLs, but they tended to wander a small amount in frequency. That frequency wander resulted in time displacements in the emissions of the various transmitters that correspondingly wandered in time. To overcome the wander, a new technique was introduced, locking the frequencies of the data streams on the DTxA output and the transmitter inputs to the same external reference (GPS). This solved the problem and then was incorporated into the ATSC standard that is based on the technology used in the WPSU-DT DTx system.

(9) Any other pertinent developments.

Since the filing of the renewal application for the experimental license, the Commission has adopted Distributed Transmission System (DTS) technology "in principal" in the Report and Order on the Second DTV Periodic Review, with the promise of a "fast track" NPRM process to adopt permanent rules for the routine authorization of such operations. It subsequently issued a "Clarification Orde,r" expanding on how interim authorizations are to be handled until permanent rules are in place, and an NPRM seeking input on the rules it proposed to adopt for routine licensing of DTS operations. It has received inputs on the NPRM, but no Report & Order yet has been forthcoming. The information provided together with this renewal application is expected to be added to the docket on the DTS NPRM as an *ex parte* filing, since the comment period in that proceeding officially has closed.